# Millstone Media Manual

Information on Millstone Power Station

Waterford, Connecticut

Revised - 2007

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# Millstone 2

| | |
|---|---|
| Net Generating Capacity: | 870 mwe |
| Cost: | $424,400,000 |
| Commercial Operation: | December, 1975 |
| Station Employees: | 1,270 |
| Reactor Manufacturer: | Combustion Engineering Inc. |
| Turbine Generator Manufacturer: | General Electric Company |
| Engineer/Constructor: | Bechtel Corporation |
| Containment Walls (Thickness): | 3.75 ft. |
| Steel Liner Thickness: | 1/4 inch |
| Height from base: | 176 ft. |
| Material: | Reinforced Concrete |
| Reactor Height: | 42 ft. |
| Reactor Diameter: | 14 ft. |
| Steel Wall Thickness: | 4 3/8 – 8 5/8″ |
| Number Fuel Assemblies in Reactor: | 217 |
| Operating Temperature: | 596 degrees F |
| Operating Pressure: | 2,250 psig |
| Uranium Fuel: | 192,000 lbs. |

# Millstone 3

| | |
|---|---|
| Net Generating Capacity: | 1,154 mwe |
| Cost: | $3,770,000,000 |
| Commercial Operation: | April, 1986 |
| Station Employees: | 1,270 |
| Reactor Manufacturer: | Westinghouse Electric Corp. |
| Turbine Generator Manufacturer: | General Electric Company |
| Engineer/Constructor: | Stone & Webster Engineering Corp. |
| Containment Walls (Thickness): | 4.5 ft. |
| Steel Liner Thickness: | 3/8 – 1/2 " |
| Height from base: | 201 ft. |
| Material: | Reinforced Concrete |
| Reactor Height: | 44.8 ft. |
| Reactor Diameter: | 14.4 ft. |
| Steel Wall Thickness: | 5 3/8" |
| Number Fuel Assemblies in Reactor: | 193 |
| Operating Temperature: | 596 degrees F |
| Operating Pressure: | 2,235 psig |
| Uranium Fuel: | 222,645 lbs. |

# 1

## Fundamentals of Nuclear Power

The basics of a nuclear power plant are identical to those of a coal or oil fueled unit: water is heated to steam; the steam is directed to the blades of a turbine, causing the turbine to spin; the spinning turbine turns a magnet inside huge coils of wire, producing electricity. The major difference is the source of the heat: in a nuclear power plant, the heat comes not from the burning of a fossil fuel, but from the splitting of the nucleus within the uranium atom, a process called nuclear fission.

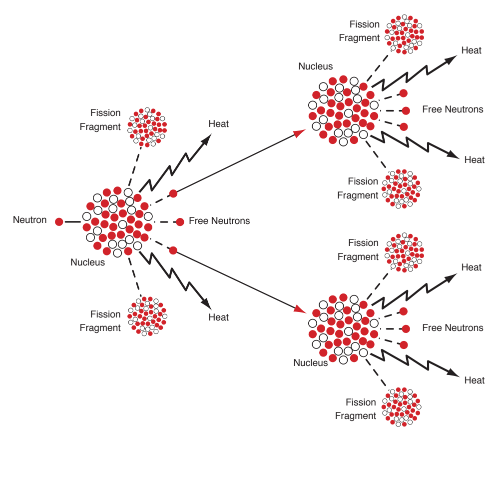
As a brief review, atoms are made of three fundamental particles: protons, neutrons, and electrons. The central part of the atom, the nucleus, consists of protons – particles with positive charge, and neutrons – particles with no charge. Spinning around the nucleus are electrons – particles with negative charge. The electrons are kept in orbit around the nucleus by an electrical force; that is, the negative charge of the electrons is attracted to the positive charge of the protons in the nucleus. The protons and neutrons within the nucleus, however, are held together by a much stronger nuclear force. It is this force that is released as heat energy when a nucleus undergoes fission.

### Fission Process

Fission occurs when a neutron strikes and is absorbed by the nucleus of a Uranium-235 atom. This extra neutron causes that atom to become unstable, and it almost immediately divides into two or more smaller atoms called fission products. This process releases heat, radiation, and two or three more neutrons. Under controlled conditions, these neutrons can be absorbed by other Uranium-235 atoms, causing them to split, releasing more neutrons, splitting more atoms, and so on. Thereby, continuous fissioning can take place—a chain reaction.

### Typical Fission Products And Their Half Lives

| | |
|---|---|
| Iodine-131 | 8 days |
| Krypton-85 | 11 years |
| Hydrogen-3 | 12 years |
| Strontium-90 | 28 years |
| Cesium-137 | 30 years |



In order for a neutron to cause fission, it must be slowed down before it can be absorbed by a Uranium-235 atom. This slowing down is accomplished through the action of a moderator. Neutrons collide with the atoms of the moderator, giving some of their energy to the moderator and in the process, slowing down.

In order to understand the importance of slowing down the neutron, it can be compared to a meteor traveling through space. If the meteor is traveling very fast as it approaches the gravitational pull of the earth, its speed will be too great to be overcome by the earth's gravity, and it will simply pass by without being "captured" by the planet. If it is traveling slowly, however, the earth's gravitational pull can overcome the speed of the meteor and pull it into the planet. Capture of a neutron by a nucleus is similar, except that nuclear forces rather than gravity are involved.

In all U.S. commercial nuclear power plants, the same water that is heated in the reactor is used as a moderator. Ordinary or "light" water is used; it is different from "heavy" water (deuterium oxide), used in some nuclear plants of different design. The fission process is controlled by neutron-moderating and neutron-absorbing materials.

## Reactor Design

In a Pressurized Water Reactor, control is accomplished by neutron absorbing material mixed in the water flowing through the reactor; the control rods of a PWR are primarily for startup and shutdown purposes.

The water flowing through the reactor is heated under pressure to keep it from boiling. If the water boiled it would not be capable of moderating neutrons and reactor power would decrease.  This primary system water flows to steam generators where its heat is transferred through the walls of tubes to another body of water, the secondary system, which is allowed to boil. The resulting steam drives the turbine that spins a generator and produces electricity. The steam leaves the turbine and passes through a condenser where it is cooled and changed back into water. Pumps return the secondary system water to the steam generator for reheating and reuse in the plant cycle.

Both Millstone Units 2 and 3 are a PWR design.

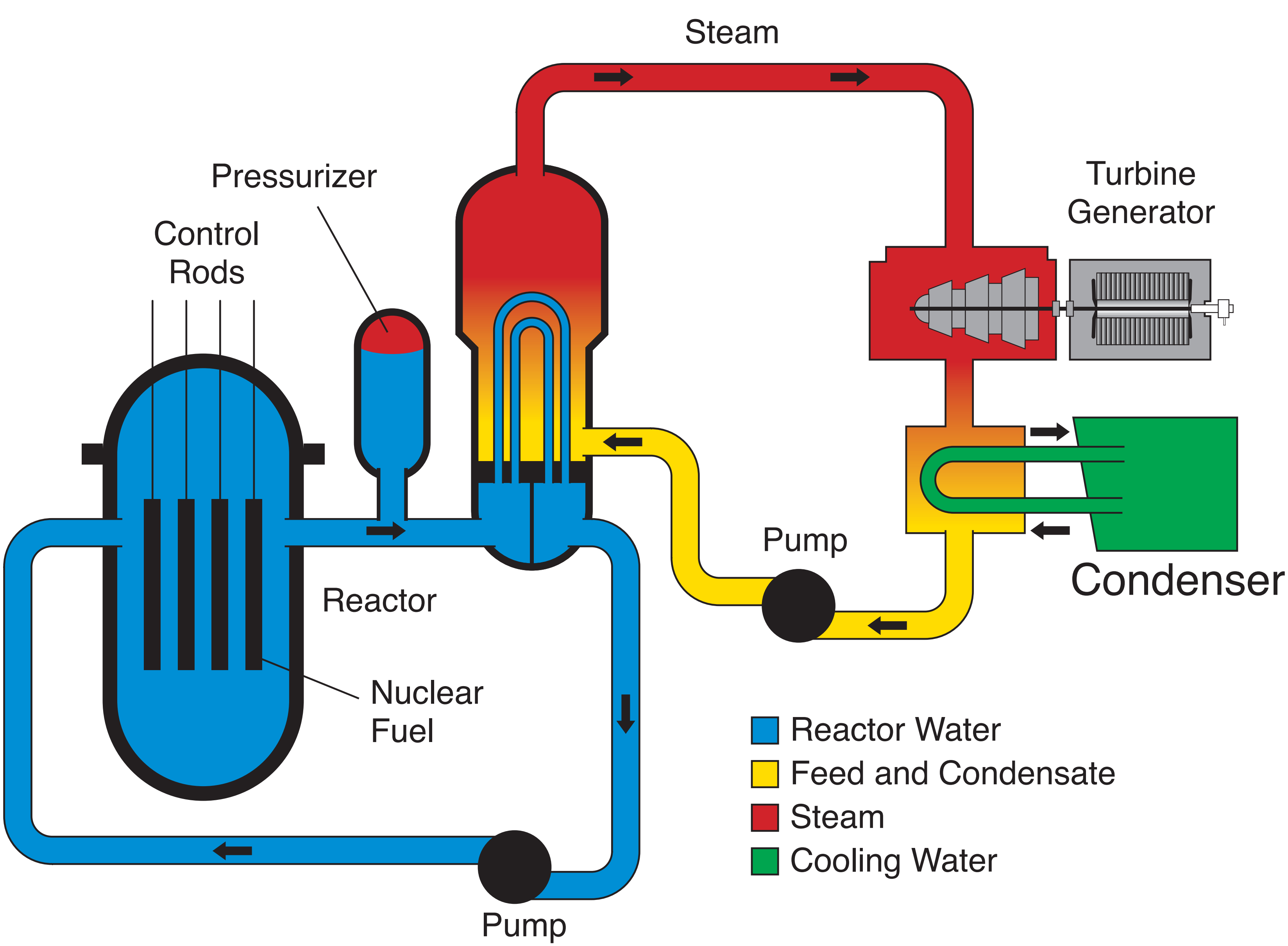
Millstone Unit 1 is a decommissioned Boiling Water Reactor.

## Nuclear Fuel Cycle

### Uranium

There are several types of uranium (U) atoms, all with 92 protons and all virtually identical chemically, except for the number of neutrons. These different forms of the same element are called isotopes. In nature, uranium is mostly U-238 (more than 99%) and U-235 (less than 1%).  The numbers 235 and 238 refer to the total number of neutrons and protons in the nucleus. The U-235 nucleus can be fissioned relatively readily by absorbing a neutron. U-238, on the other hand, is much more difficult to fission.

## Pressurized Water Reactor (PWR) — Millstone Units 2 & 3



In order for a fission reaction to sustain itself, there must be a sufficient quantity of fissile material (isotopes that can undergo fission). The minimum amount of fissile material required to maintain a chain reaction is called critical mass. The critical mass depends on a number of conditions and can vary from one reactor to another, but each reactor has a specific value for its critical mass.

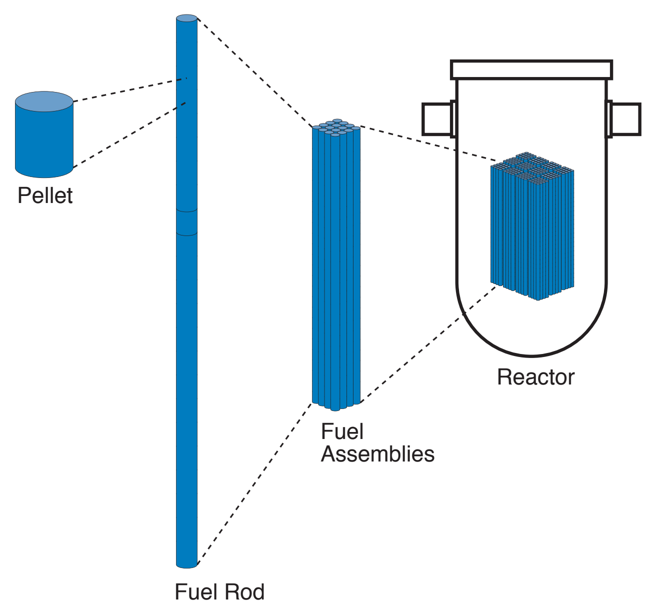
If a reactor were loaded with exactly the amount of fuel needed for critical mass, some of the fuel would soon be used up, the amount of fuel would drop below critical mass, and the reaction would die out. To avoid this situation, the reactor is loaded with sufficient extra fuel to continue operating for up to 24 months without refueling.

## Enrichment

The uranium used in commercial light water reactors is enriched to about 3-5% U-235 so that the chain reaction can be initiated and maintained. In other words, through a series of chemical and physical processes, the amount of fissile U-235 is increased from about 0.7% as it exists in nature to about 3-5% by weight. Almost all of the remaining uranium is the non-fissile U-238. Although it is possible to maintain a chain reaction at the relatively low level of purity, the fuel is simply not concentrated enough to cause a nuclear explosion.

## Fuel Manufacture

The fuel in a nuclear reactor is uranium dioxide that has been fabricated into small, cylindrical pellets, each about one-half inch long by three-eighths inch in diameter. These pellets are in ceramic form and have a melting point of 5,180 degrees F. The pellets are stacked in twelve-foot long corrosion-resistant metal tubes that are able to endure temperatures of approximately 2,100 degrees F without deteriorating. These tubes, known as fuel rods, are filled with non-reactive helium gas, sealed, and thoroughly inspected before being bundled together into assemblies. These assemblies are then arranged in the reactor, making up the reactor core. For comparison purposes, the energy potential of one pound of uranium is roughly equivalent to that of a quarter-million gallons of oil or 1,300 tons of coal. If this pound of uranium could be completely fissioned, it would release 35 billion BTU's, which, if it could be completely converted to electricity, would generate more than 10 million kilowatt-hours. Because nuclear power plants typically operate at about 33% efficiency, however, only about 3.3 million kilowatt-hours of electricity would be generated; the remainder of the energy would be lost as heat. Fossil fuel plants usually operate at closer to 40% efficiency.



## Fission Products

The fission products produced as a by-product of the fission process are much more radioactive than the original uranium fuel, and they begin to decay and emit radiation immediately. The solid fission products are contained within the original ceramic pellets along with the uranium; the gaseous fission products may escape from the pellet itself, but are contained within the fuel rods. Because these fission products continue to produce heat (known as decay heat) even when the reactor has been shut down and the chain reaction has been stopped, coolant flow through the reactor must be maintained.

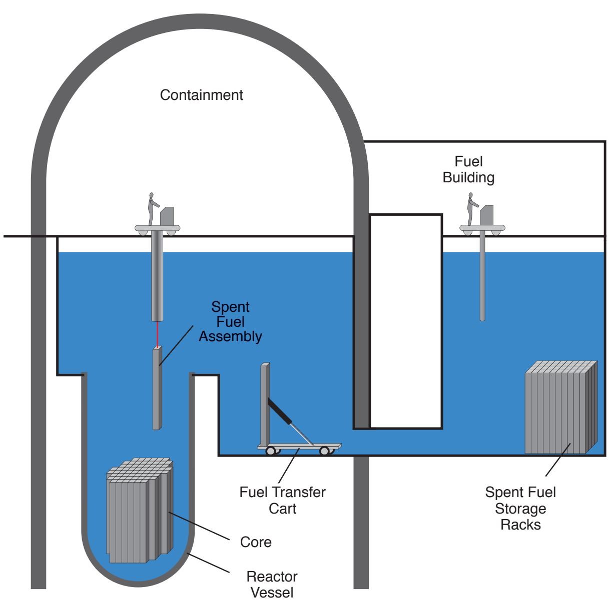
There are approximately 80 fission products produced in a nuclear reactor. The half-life, is the time it takes for half of the radioactivity of a substance to decay or disappear. As these substances decay, the radiation emitted is converted to heat in the material surrounding the fuel. Generally, the more unstable (and hence, more radioactive) a substance is, the more quickly it decays and the shorter is its half-life. Some fission products have a half- life of less than a second others have a half-life of thousands of years.

## Refueling

During operation of nuclear plants, the fissile material in the fuel is eventually depleted and must be replaced. The length of time between refuelings varies, depending on the design of the reactor and the fuel itself, but is generally in the range of 18 to 24 months. At that time, the plant is shut down and the refueling process takes place.

During refueling, the top of the reactor vessel is removed and the large, stainless steel-lined cavity that contains the vessel is flooded with water. A fuel-handling crane above this cavity is used to move the fuel. Each refueling, approximately one-third of the fuel assemblies are removed from the vessel and replaced with fresh assemblies. In addition to refueling the reactor, a large number of maintenance and surveillance jobs are scheduled.

## Refueling



## Spent Fuel Storage

Used or spent fuel must be stored in a manner that isolates it from the public and the environment because of its high level of radioactivity. Presently, it is stored in a spent fuel pool located near the refueling cavity of each plant. The pool is filled with water, and the fuel assemblies are lowered into storage racks in the pools. The racks, along with neutron-absorbing materials in the water, serve to prevent the fission process from recurring. The water also cools the fuel, and acts as a very effective radiation shield for workers at the plant.

Over time the spent fuel becomes less radioactive. Millstone is in the process of moving older spent fuel into dry storage. (See Dry Cask Storage.)

## Dry Cask Storage Of Spent Fuel

In 1988 Dominion became the first company in the United States to develop interim dry storage of used nuclear fuel at the Surry Power Station in southeastern Virginia. Since that time similar storage facilities have been constructed at 25 locations in the United States including the Connecticut Yankee site in Haddam Neck, Millstone Power Station, and Dominion's North Anna station in central Virginia.

Dry storage is an interim measure for safely storing used fuel until the U.S. Department of Energy (DOE) is ready to accept the material at the federal underground repository. The DOE currently is preparing an application to the U.S. Nuclear Regulatory Commission to build a repository in Yucca Mountain, Nevada.

Dominion safely stores used nuclear fuel from Millstone Unit 2 in rugged Horizontal Storage Modules developed by Transnuclear. These modules are steel-reinforced concrete bunkers that are 128 feet high, 8.5 feet wide and 20 feet deep, with walls and roof up to 5 feet thick. The modules are located within the highly secure Protected Area of the Millstone station.

The fuel is placed in a steel canister that is capable of holding 32 fuel assemblies. Once filled, the lid on the canister is seal-welded in placed to ensure the radioactive material is permanently isolated from the environment. The canisters, which weigh more than 40 tons fully loaded, are then inserted into a Horizontal Storage Module.

Once the fuel is sealed in the canister it will never be touched again before being shipped by the DOE to the federal used fuel repository. The canisters can be easily transferred from the Horizontal Storage Modules to heavily shielded transport casks for shipment to the repository.

Dominion intends to build storage space on an as-needed basis. When full, the first phase of storage will include 20 Horizontal Storage Modules. The facility could accommodate a maximum of 135 modules.

## Decommissioning

(Source: May 2002 , Key Facts –from the Nuclear Energy Institute)

### Decommissioning: What's Involved?

After a nuclear power plant is permanently shut down, it must be decommissioned.

This entails two steps:

First, the company that operates the plant either decontaminates or removes contaminated equipment and materials. It also places the used nuclear fuel in dry storage until its final disposal. These materials and equipment account for more than 99 percent of the plant's radioactivity. Their removal lowers the level of radiation and thus reduces the exposure of workers during subsequent decommissioning operations.

In the second step, the company deals with the small amount of radioactivity remaining in the plant, which must be reduced to harmless levels through a cleanup phase-decontamination.

In decontamination, workers remove surface radioactive material that has accumulated inside pipes and heat exchangers or on floors and walls, and was not decontaminated during normal plant operations because of inaccessibility or operational considerations. They are aided in decontamination activities by the records that plants are required to keep during operation. Workers use chemical, physical, electrical and ultrasonic processes to decontaminate equipment and surfaces. The removed radioactive material is concentrated, packaged, and transported for disposal at a low-level radioactive waste disposal site.

Concentration cuts the volume of low-level radioactive waste, thus reducing the expense of disposal.

### Experience to Date

Since 1960, more than 70 test, demonstration and power reactors have been retired throughout the United States. These include more than 40 research reactors ranging in size from less than a watt to two megawatts, four demonstration nuclear power reactors (the largest, 256 megawatts), as well as a number of large commercial nuclear power plants.

In addition to the reactors already decommissioned, there are 17 power reactors either in or entering the decommissioning phase:

Reactors using the SAFSTOR approach to decommissioning are: Dresden 1, Illinois; Fermi 1, Michigan; Humboldt Bay, California; Indian Point 1, New York; LaCrosse, Wisconsin; Millstone 1, Connecticut; Peach Bottom 1 and Three Mile Island 2, Pennsylvania; and Zion 1 and 2, Illinois. Decommissioning of some of these reactors may not occur in the near term. In some cases, that is because other nuclear units are still operating on the same site, and the owner has decided to wait until those reactors are shut down before starting decommissioning. In other cases, companies are still accumulating the funds needed for decommissioning.

## Millstone Unit I

In accordance with federal regulations, Millstone Unit 1 submitted certification to the NRC that as of July 1, 1998, power operations had permanently ceased and fuel had been permanently removed from the reactor vessel.

### Regulatory Requirements

Since decommissioning a nuclear power plant is essentially "construction in reverse," particular emphasis is placed on ensuring industrial safety. Throughout the decommissioning process, regulatory oversight is provided by the Occupational Safety and Health Administration, the Department of Transportation and the Environmental Protection Agency, as well as the NRC.

## Funding Requirements

NRC funding requirements are specifically related to that portion of a nuclear plant that has been contaminated by radioactive material. The NRC does not require companies to include funds for dismantling buildings and facilities (such as office buildings and switchyards) that do not pose a radiation hazard to workers.

Beyond the health and safety issue, the nuclear industry considers the adequate collection of decommissioning funds an obligation-one agreed to by electric companies and their regulators the moment each nuclear power plant began to operate. So far, all states that have restructured their electric power industries have made explicit provision for continued collection of unfunded decommissioning costs in rates. The typical mechanism is some form of "wires" charge to consumers, who for years have enjoyed the benefits of nuclear-generated electricity in a cost-of-service environment.

# 2

# Fundamentals of Radiation

## Ionizing Radiation

The smallest, most basic part of an element is the atom. Atoms are made up of three main parts: protons, neutrons, and electrons. Protons, which have a positive electrical charge, and neutrons, which have no electrical charge, exist in the nucleus of the atom. Electrons, the smallest part of the atom, have a negative electrical charge and orbit around the nucleus. These orbital electrons determine chemical properties of elements.

The number of protons in the nucleus determine what the element is, and the neutrons provide stability to the nucleus. Most elements in nature, have just the right number of protons and neutrons to remain stable. Some elements, however, do not. These elements have either too many neutrons or protons, or too much energy in the nucleus, to be stable. Unstable or radioactive elements go through a process called decay to become stable. During radioactive decay the atom may emit one or more of the extra protons or neutrons, or shed some excess energy. This energy has the ability to change other atoms.

Radiation can cause an effect called ionization. Atoms that have equal numbers of electrons and protons are electrically neutral. If an electron is stripped from an electrically neutral atom, the result is, electrically charged particles. Ionization is the breaking of an electrically neutral atom or molecule into electrically charged components called ions. The type of radiation that ionizes atoms is referred to as ionizing radiation.

## Types Of Ionizing Radiation

There are four types that we may encounter in a nuclear power plant: alpha, beta, gamma, and neutron. All four types of radiation that we will discuss cause ionization, either directly or indirectly.

### Alpha

Alpha radiation is a particle type of radiation and is composed of two neutrons and two protons. Alpha radiation is released during the decay of certain radionuclides that are part of the fuel or are produced in the fuel rods as a consequence of the nuclear fission process. Because alpha particles are relatively heavy (>4 times the mass of a neutron) and because they have a high charge (+2), they are easily stopped (shielded). In air, alpha particles travel only 1 to 2 inches and, in general, cannot penetrate a sheet of paper or the outer layer of the skin. Radionuclides which decay by the emission of an alpha particle are usually contained within the fuel rod and by the fuel cladding. Alpha radiation can become an internal exposure concern if alpha emitting material is taken into the body (e.g., by ingestion or inhalation).

### Beta
Beta radiation is a particle type of radiation, with the size and electrical charge of an electron. Beta radiation is released from a wide variety of radionuclides produced during the nuclear power generation process including some fission products and corrosion activation products. Although beta particles are relatively light (~1/2000 of the mass of a neutron) their charge (-1) makes them relatively easy to stop. Beta can be shielded with plastic, heavy clothing, or even thick layers of paint. Many of the beta particles found in the plant can only travel 2 to 3 feet in air. Beta radiation can be an external exposure concern for the unprotected skin or the lens of the eye. It can become an internal exposure concern if beta emitting material is taken into the body.

### Gamma
Gamma radiation, which is similar to X-ray, is a wave type of radiation. Gamma radiation is released from a wide variety of radionuclides produced during the nuclear power generation process, including some fission products and some corrosion activation products. Because gamma radiation has no mass or charge it can travel a relatively large distance. Dense material such as lead, steel and concrete is used to shield gamma. This is the most common type of radiation encountered in a nuclear power plant and is primarily an external exposure concern, but may become an internal exposure concern if gamma emitting material is taken into the body.

### Neutron
Neutron radiation is a particle type of radiation. Neutrons are released from the atom during the fission process that is used to generate heat in the reactor core. Because neutrons have a charge of zero, they may travel a relatively large distance before being stopped and will be found in the reactor containment building and a few isolated but accessible areas of the plant. Material containing hydrogen is an effective shield for neutrons. During periods when the reactor is shut down, the fission process is stopped and neutron radiation exposure is not a concern. Neutron radiation is an external exposure concern.

## Sources Of Radiation
Materials that emit radiation are mostly contained within the fuel assemblies, but some can end up in primary system components, such as the reactor vessel and coolant piping. Materials in the vicinity of the reactor or in the coolant can become radioactive due to interactions with neutrons that are released from fission.

Nuclear power plants are not the only source of radiation. People have always been exposed to radiation. Cosmic radiation from the sun and space as well as naturally occurring radioactive material in the soil, rocks, and even the food we eat contribute to our annual dose. The annual dose to a member of the US population from these natural background sources, plus medical exposure, averages about 360 millirem per year.

## Radioactive Material
Radioactive material is material that emits radiation. Contamination is radioactive material in an undesirable location. It is useful to keep the difference between radioactive material and contamination in mind.

## Radiation Measurement
**Radiation** – The Rem, is a measure of the "biological effect" caused by the radiation the body is exposed to. Generally, a smaller unit of the rem is used; the

millirem (mrem). One millirem is 1/1000th of a rem. This is similar to the use of meters and millimeters. The Roentgen is a measure of ionization in air and is the same as Rem for gamma radiation.

**Radioactive Material** – The units disintegrations per minute (DPM), counts per minute (CPM) and Curie (Ci) are used to measure amounts of radioactive materials well as contamination.

## Radiation Exposure

### Dose Rate

As miles-per-hour is an expression of travel rate, so millirem-per-hour is an expression of dose rate. If the dose rate is 50 millirem-per-hour, and we stay in the area for one hour, then our dose would be 50 millirem

### Dose

The amount of radiation a person is exposed to, is referred to as dose, or dose equivalent. It is similar to being out in the sun at the beach. We may say that you were, "exposed," to the sun. The result of that exposure to the sun could be a "dose" of sunburn. As explained before, dose or exposure is expressed in units of rem or millirem. For example, a worker might receive a dose of 100 millirem. In this document, dose and exposure are used interchangeably.

### External Dose

Radiation received from sources outside the body results in external dose. Most of the dose to nuclear power workers is from external exposure. The amount of time spent in any given radiation area will affect our external exposure. External dose is called Deep Dose Equivalent (DDE).

### Internal Dose

Workers may receive internal dose in addition to external dose. When radioactive material is ingested or inhaled, radiation exposure results from the material that is inside the body. Internal dose is called Committed Effective Dose Equivalent (CEDE).

### TEDE

If the external dose and the internal dose are added together, the result is the individual Total Effective Dose Equivalent or TEDE. Workers are normally limited by federal law to 5,000 millirem TEDE per year.

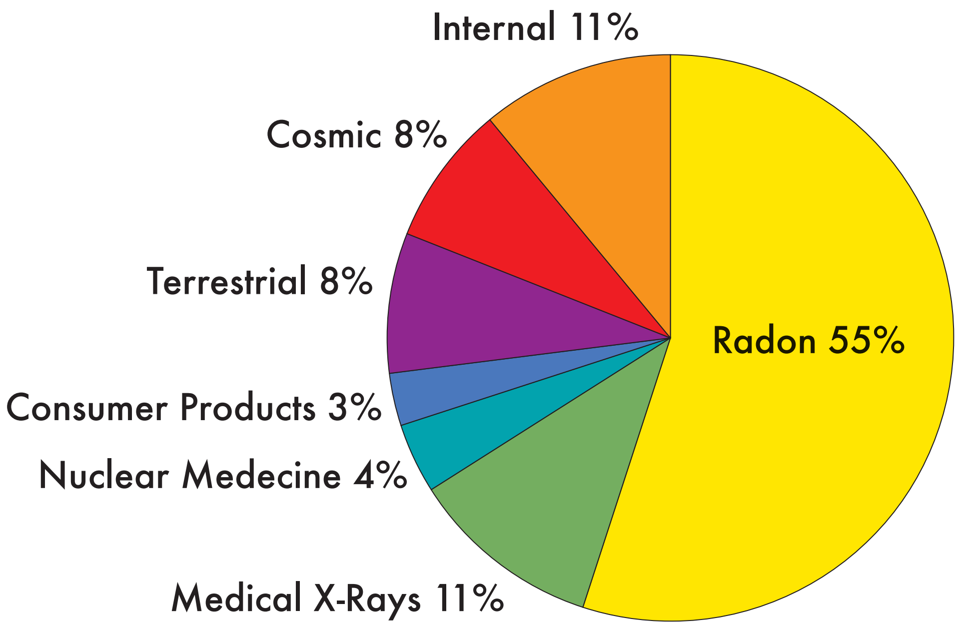
Additional detail related to types of dose and associated limits can be found in Title 10 of the Code of Federal Regulations, Part 20 (10 CFR 20)

## Biological Effects

Radiation exposure plays a role in our everyday lives, whether we work in an occupation that involves radiation exposure or not. We are constantly exposed to radiation from the sun, soil, and the food we eat. In addition to these natural sources of radiation, there are a number of man made radiation sources. These include exposures from medical X-rays, television sets, cigarettes, building materials, and fallout from previous atomic bomb tests. The level of radiation exposure people may receive from these sources varies from fractions of a millirem to several rem.

Radiation exposure involves some risk. When we discuss the risks related to radiation exposure, the concerns are cancer, cataracts, and the increased chances of genetic effects. There is additional information available in the NRC Regulatory Guide 8.29 “Instruction Concerning Risk From Occupational Radiation Exposure”.

## Sources Of Radiation




The average American receives about 360 millirem per year.
Source: USNRC (http://www.nrc.gov/reading-rm/basic-ref/glossary/exposure.html)

## Radiation And Cell Interaction

To fully understand the potential risks involved with radiation exposure, we first must understand the way in which radiation interacts with the human body. These factors include the type of radiation, the energy of the radiation, the type of cell and the general condition of the cell.  Another factor to consider is that when radiation exposure is received in small quantities over a long period of time, biological repair can occur.

## Prenatal Exposure

Genetic effects should not be confused with exposure to the embryo/fetus. Chronic radiation exposure to the rapidly developing cells of the human embryo fetus have been observed to increase the chance of abnormalities. In fact, it has been observed through studies of exposure to x-rays, that radiation exposure to the embryo-fetus results in increases in the risk of childhood cancer, small head size, and mental retardation. A radiation worker who is pregnant or expects to become pregnant needs to consider the risk of radiation exposure to herself and to the embryo-fetus as well. Additional information is available in the NRC Regulatory Guide 8.13.

## Estimated Risk of Fetal Irradiation

| Occurance per 1,000 Children | | | |
|---|---|---|---|
| Problem | Natural | 500 mrem | 5,000 mrem |
| Childhood Cancer Death | 1.4 | 1.7 | 4.4 |
| Small Head Size (Exposure at 4-7 weeks) | 40 | 42.5 | 65 |
| Small Head Size (Exposure at 8-11 weeks) | 40 | 44.5 | 85 |
| Mental Retardation (Exposure at 8-15 weeks) | 4 | 6 | 24 |

### Cell Response

When a cell of the body is exposed to radiation, a number of things could happen to it. The radiation may have no effect at all, the cell may be damaged and repair itself, or it could die from the damage. The potential for repair depends on the extent of the damage. In some circumstances, the cell will change, or mutate. When a mutation occurs, it may or may not affect the cell's ability to function as it was intended, and it may or may not be passed on to the next generation of cells. The body tends to eliminate cells whose function has been impaired.

### Radiosensitivity

A cell's sensitivity to radiation, or radiosensitivity, depends upon many factors: If the cell is in the process of dividing, the rate at which it is dividing, the stage of the cells' life, and the type of cell. Young, rapidly maturing tissue cells are the most radiosensitive. A good example of young, rapidly maturing tissue cells is found in the embryo-fetus. Cells develop very rapidly during the earliest stages of pregnancy and this is when the cells are most radiosensitive. As a person ages, the rate of cell reproduction, and therefore, radiosensitivity, decreases. It is for this reason that specific limits for radiation exposure to declared pregnant radiation workers have been established.

It is important to distinguish between dose to the whole body versus that received locally to a particular part of the body, e.g. the hands, the feet, or to a specific organ, such as the lung or the GI tract. It is the nature of the biological effect of radiation that local organs can withstand a much larger dose of radiation delivered locally than the whole body. The same amount of radiation, if given to the whole body, can result in more serious biological damage. For this reason, the radiation limits for the whole body are much lower than those for specific organs.

### Types Of Radiation Exposure

When discussing the risks and effects of occupational radiation exposure, it is important to understand the two types of radiation exposure; chronic and acute.

#### Chronic Exposure

Chronic radiation exposure is defined as small exposures of radiation received over a long period of time, for example, a few rem per year over an eight year period. The dose received from natural background radiation sources is considered chronic. The average radiation worker in nuclear power stations receives an occupational dose of approximately 170 millirem per year. Chronic radiation exposures do not result in prompt effects, because the body is able to repair the damage that occurs, but it may result in delayed effects which appear in ensuing years. Radiation exposure to workers from routine plant maintenance are chronic radiation exposures.

### Acute Exposure

Acute radiation exposures are large doses of radiation received in a very short period of time. When an individual has received an acute radiation dose, there may be prompt effects, as well as delayed effects. Prompt effects (effects that are observable shortly after an acute exposure) which have been observed are as follows:

- For individuals receiving less than 25 rem, (25,000 millirem) biological effects are difficult to observe.
- In persons receiving 50 to 100 rem of acute exposure, slight changes in the white blood cell count is the only observable effect. A very small percentage may experience nausea.
- Some people receiving 100 to 200 rem in a short period of time will experience vomiting within three hours of exposure and moderate blood changes. Except for the blood forming system, recovery will occur in most people within a few weeks.
- In a population exposed to 450 rem, half the people will likely die within 30 days unless provided medical attention such as infection control and intravenous nourishment.
- Most people exposed to 200 to 600 rem will experience vomiting within three hours, loss of hair after two weeks, severe blood changes, hemorrhaging, and infection. Death may occur. Recovery takes between one month and one year.
- A person receiving over 600 rem will experience vomiting within one hour and severe blood changes. Without medical treatment, the probability of death within two months is 80%. Survivors convalesce over a period of time.
- A fatal outcome is almost certain at an acute dose of 800 to 1,000 rem if no medical treatment is received.

## Types Of Effects

Two terms used to categorize effects due to radiation exposure are somatic and genetic.

### Somatic Effects

The term somatic refers to effects that result to the individual that receives the exposure. Somatic effects may be prompt or delayed. Prompt effects are associated with acute radiation exposure. The effects appear immediately or within a few months. Delayed effects appear months or years later.

The National Academy of Sciences presented a report in 1990 entitled "Biological Effects of Exposure to Low Levels of Ionizing Radiation" or BEIR 5. This report estimated that if one hundred thousand workers received yearly doses between 100 and 500 millirem per year from the age of 18 through age 65, we should expect between 4 and 20 additional cancer deaths each year above the normal expectation of about 480 cancer deaths per year. These deaths would be considered somatic effects of chronic radiation exposure. How cancer is caused is not well understood. It is impossible to tell whether a given cancer was caused by radiation exposure or by some other of the many causes. Most cancers are probably caused by a combination of several factors; general physical condition, inherited traits, age, sex, diet, and exposure to cancer promoting agents, such as cigarette smoke.

Cataracts have been reported after an acute exposure of two hundred to five hundred rem of local exposure to the lens of the eye. Therefore, cataracts occur at exposure levels many times higher than those normally found at nuclear power facilities.

### Genetic Effects

Genetic effects are passed on to an individual's offspring or some future generation. The risk of genetic effects from radiation exposure is extremely low. Studies of the offspring (up to three generations) of the Japanese A-bomb survivors have shown no measurable increase in genetic effects over that observed in the general population. These survivors had received doses in the range of one rem to a few hundred rem.

## Risk Estimation

In order to remain conservative in estimating the effects of chronic radiation exposures, three assumptions are made. First, no credit is recognized for biological repair, although it is well known that biological repair does occur. Second, the effects from low level radiation exposure are linearly proportional to those that occur at high levels of exposure. Third, any amount of radiation exposure, no matter how small, carries a risk.

The majority of data used to estimate risk from occupational radiation exposure is based on observations of acute radiation exposures. Radiation is like most substances that cause cancer; the effects can only be seen clearly at high levels of exposure. There is much difficulty and many diverse opinions among scientists in determining the effects of low level radiation exposure. The safe assumption to make is that the effects of low level radiation exposure are linearly proportional to the effects seen at high exposure levels. Using this assumption, based on observation of the biological effects at high levels of exposure, we can estimate the effects that will occur at low levels.

## Controlling Radiation Dose

### Dose Monitoring

Devices used to measure a person's dose are called dosimetry. Common dosimetry includes:

- Pocket Ion Chambers (PICs) (also called Direct Reading or Self Reading dosimeters). These devices can be read by the user and provide an instantaneous estimate of exposure.

- Electronic Dosimeters are frequently used within nuclear facilities to electronically provide the user an instantaneous estimate of exposure. These devices generally have the ability to alert the user when limits are approached and can provide dose rate information.

- Thermoluminescent Dosimeters (TLDs) are used to provide a permanent record of dose. These devices are very accurate, but must be processed in a laboratory.

### Dose Rate Monitoring

Survey meters are used to determine the dose rate in an area. These are generally hand held meters but they can vary from telescopic pole design to pager size.

## Contamination Monitoring

To determine the level of contamination on an object, person or area, count rate meters are used. These devices are often called friskers and consist of a probe connected to a meter. Frisking with these devices is time consuming. Portal Monitors are devices that check for contamination as a person or object passes through.

## Time, Distance, and Shielding

Reducing time exposed to radiation or putting distance or shielding between a person and a source of radiation will all reduce the dose a person receives. ALARA is an industry-wide effort to reduce work exposure, stands for "As Low As Reasonably Achievable".

## Reducing Internal Dose

Respiratory protection can be used to prevent the inhalation of radioactive material resulting in reduced dose. When decisions on whether to use respiratory protection are made, consideration is given to the impact on external dose – it doesn't make since to wear a respirator to avoid one millirem internal if increased time causes the user to receive 10 millirem external. Attention to hygiene – keeping the hands away from the mouth, not eating, drinking or smoking etc., can prevent the ingestion of radioactive material.

## Potassium Iodide (KI)

KI is non radioactive iodine. KI could be used to basically fill the thyroid, thus preventing radioactive iodine from having any place to go in the body.

# 3

# Plant Components and Systems

## Primary System

There are two closed coolant systems: the primary and the secondary. The primary system (also called the reactor coolant system) consists of water flowing through the reactor vessel to steam generators, where heat is transferred to a second coolant loop, the secondary system. This secondary system water boils into steam, which flows to the turbine-generator, produces electricity, is condensed back into liquid, and is returned to the steam generators.

## Reactor Vessel

The reactor vessel, which houses the core of nuclear fuel assemblies, is made of carbon steel and is lined with stainless steel. It is cylindrical in shape and three to nine inches thick. The fuel assemblies are placed in the vessel in a precise geometric configuration designed to allow the fission process to take place and to efficiently utilize the fissile materials within the fuel.

The vessel also contains control rod assemblies made of a special neutron-absorbing alloy and enclosed in stainless steel. Under a wide range of circumstances, varying from a minor deviation from normal operating conditions to an emergency situation, the reactor will receive a signal to immediately shut down, known as a trip or scram. If such a signal is received, all the control rods are automatically inserted into the core and the reaction ceases immediately.

## Reactor Control

Control of the reactor is accomplished primarily by the introduction of neutron absorbing materials in the reactor system.   Boric acid, a neutron-absorbing chemical, is added to the water flowing through the reactor. The control rods are used primarily for startup and shutdown purposes. The role of the water itself in the fission process can also contribute to reactor control. Water, as the moderator, is a necessary part of the fission reaction. If the water is lost, the reaction automatically ceases. Even an increase in temperature, which makes the water less dense, can slow down the fission reaction.

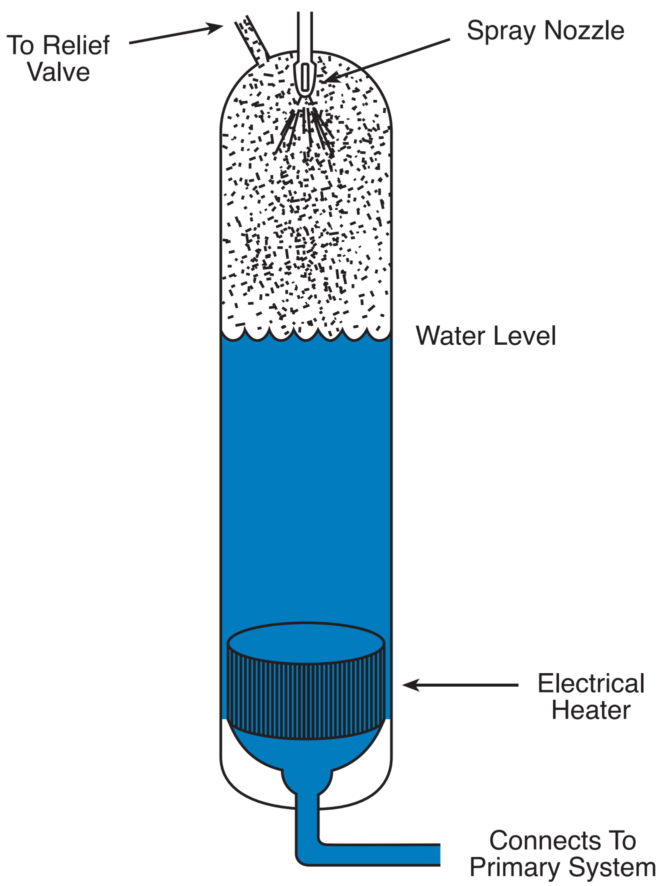
## Reactor Protection

Nuclear plants are designed and operated for maximum efficiency; however, conditions, known as transients, such as equipment failures, operator error, or external factors (such as storms or loss of electrical power) may cause deviations from normal operating condition. To prevent these transients from affecting public safety, the plants are designed to automatically shut down whenever plant conditions exceed conservatively set operating boundaries. A deviation in power, pressure, temperature, water level, steam flow or coolant flow can cause an automatic shutdown, or trip. The reactor also can be tripped manually if an operator perceives a potentially unsafe condition or one that could damage plant equipment. A reactor trip is accomplished by rapidly inserting the control rods into the reactor core, which immediately stops the chain reaction.

## Pressurizer

The primary (reactor) coolant system is kept under high pressure (approximately 2,200 pounds per square inch, or psi) to prevent boiling. This pressure is accomplished and controlled by a component called a pressurizer. Inside the pressurizer, electrical coils heat the water to a higher temperature than the rest of the primary system, forming a large steam bubble in the top of the pressurizer. This is the only place that steam exists in the primary system, and it always remains in the pressurizer. System pressure can be reduced by sending water through spray nozzles in the top of the pressurizer, which cools the steam bubble and causes some of it to condense. The smaller steam bubble exerts less hydraulic force on the water, lowering system pressure.

### Pressurizer



## Steam Generator

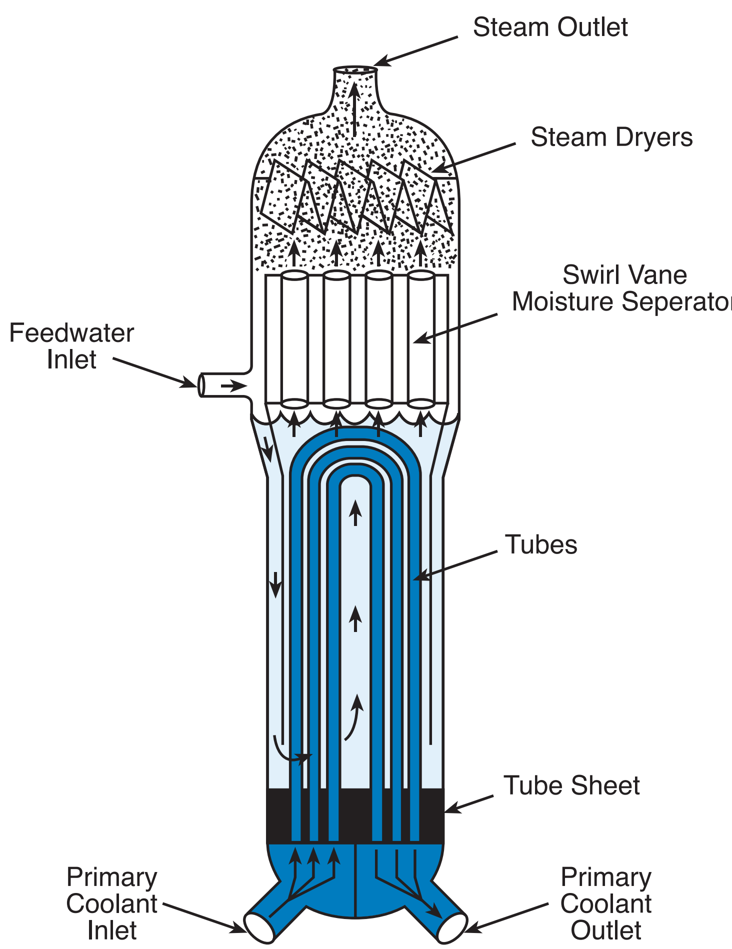
The primary system water is heated to approximately 550 to 600 degrees Fahrenheit (F) as it flows through the reactor core. It then flows to steam generators where it transfers its heat to the secondary system.

The steam generator is simply a heat exchanger between these two systems. Heated primary system water flows through thousands of U-shaped tubes in the steam generator, which serve as a boundary between the two systems. The heat is transferred through the tubes to the secondary system, which boils into steam.

The primary system water is then pumped back into the reactor vessel, approximately 50 to 60 degrees cooler than when it entered the steam generator.

The steam goes through moisture extraction devices, located in the upper area of the steam generator, which dry the steam. At this point, the steam—at approximately 500 to 550 degrees F—is sufficiently dry to go to the turbine-generator.

### Steam Generator



## Reactor Coolant Pumps
Primary system water that has gone through the steam generator is pumped back into the reactor vessel by reactor coolant pumps. These pumps are designed to pump large volumes of water at high temperatures and pressures.

## Secondary System
### Main Steam Isolation Valves
There is one set of main steam isolation valves (MSIVs), located in the main steam lines that also closes in the event of a high steam flow signal. Because the steam is not a part of the primary system, however (i.e., not radioactive), the MSIVs do not serve any containment function; they simply prevent excess steam production in the steam generators.

### Turbine Stop And Control Valves
Steam entering the turbine building travels through two sets of valves prior to entering the turbine-generator. The turbine stop valves are normally completely opened, but will close on a signal from a variety of systems. The purpose of these valves is to interrupt steam flow to the turbine to prevent it from over speeding when the generator stops generating electricity.

The turbine control valves are normally partially opened during operation. They throttle the steam flow to the turbine and control the pressures in the steam lines.

### High-Pressure Turbine
Steam enters the high-pressure turbine casing and hits the blades of several successively larger sets of turbine blades, turning the shaft of the turbine-generator. During operation, the shaft spins at the rate of 1,800 revolutions per minute (RPM), in order to maintain the generator's electrical output at a constant frequency. By the time the steam hits the last stage of the high-pressure turbine, it has lost a great deal of its energy, and has begun to condense.

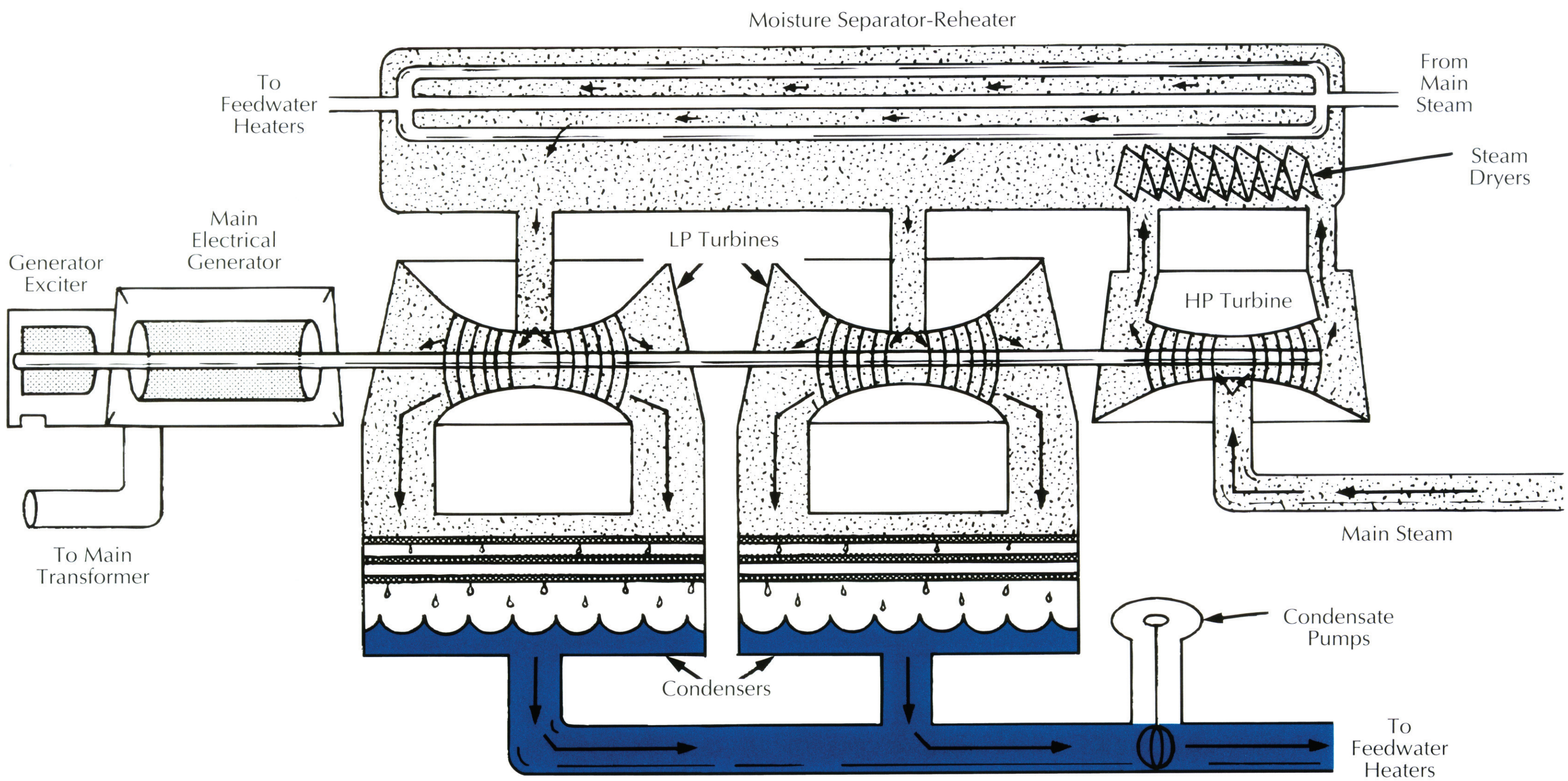
### Moisture Separator-Reheater
Moist steam leaving the high-pressure turbine flows to the moisture separator-reheater. The steam goes through moisture extraction devices that condense approximately 10% of the steam. It is then reheated as it passes by hundreds of tubes carrying hot steam tapped off the main steam lines. At this point, the steam is sufficiently dry to go to the low-pressure turbines.

### Low Pressure Turbines
Steam leaving the moisture separator-reheater is sent to either two or three low-pressure turbines (Millstone 2 has two and Millstone 3 has three). It then passes through a series of turbine blades (usually seven or eight sets) attached to the turbine-generator shaft, further contributing to the energy of the spinning turbine.

Combined intercept valves between the moisture separator-reheater and the low-pressure turbines serves the same purpose as the turbine stop valves: on the proper signal, they close to prevent steam in the moisture separator-reheater from spinning the turbine too fast on a loss of electrical generator load.

By the time the steam has passed through the last set of blades, its useful energy has been converted to rotation of the turbines, and it is at a very low temperature (approximately 100 degrees F) and pressure (very close to a vacuum). It is able to remain in steam form at this temperature because of the extremely low pressure. At this point, the remaining task is to condense it back into liquid for reuse in the plant.

# Turbine Generator



### Condensers
Below each low-pressure turbine is a condenser containing thousands of long tubes, approximately 40 to 50 feet long and one inch in diameter. Cool water from an outside source flows inside these tubes, while steam exhausting from the turbines condenses on the outside of the tubes and drops to the bottom of the condenser. From there it will be recycled back into the plant. Millstone's outside source of cooling water is the Long Island Sound.

### Electrical Generator
The electrical generator, attached to the same shaft as the turbines, converts the mechanical energy of the spinning shaft to electrical energy. Inside the generator a large electromagnet spins inside huge coils of wire. The magnetic field moving across the coils of wire produces electricity in the coils. This electricity, with a voltage of approximately 24,000 volts, travels to the main transformer where it is converted to approximately 345,000 volts, suitable for transmission across long distances.

The amount of electricity produced is controlled by the strength of the magnetic field: the stronger the magnetic field, the more electricity is produced. The magnetic field strength is controlled by an adjustable electrical device called the generator exciter. When electricity is produced in the coils surrounding the electromagnet, it produces a magnetic field of its own. The interaction of these two magnetic fields provides a very strong resistance to rotation of the turbine-generator shaft, which is why high-pressure steam is necessary. If the generator suddenly stops producing electricity, this resistance disappears and, if the flow of high-pressure steam to the turbines continued, an acceleration of the turbine, or over speed, would result. This condition is prevented by an automatic closure of the turbine stop valves and the combined intercept valves.

## Condensate And Feedwater
The overall function of the Condensate and Feedwater Systems is to return the condensed steam from the condensers back to the boiling device or steam generators. This water, known as condensate, is purified and reheated prior to being recycled.

### Condensate Pumps
The condensate pumps take water from the condensers and pump it into a series of feedwater heaters.

### Feedwater Heaters
Condensate goes through a series of five or six feedwater heaters before being sent back to the steam generators to be reboiled. Each heater heats the water to a slightly higher temperature than the previous one.  These heaters are similar in configuration to steam generators in that they have U-shaped tubes inside a shell. The condensate flows inside the tubes and is heated by steam outside the tubes, which has been tapped off various stages of the turbine.

By the time the water goes through the last feed water heater, it has been heated to more than 400 degrees F. The preheating of this water greatly increases the overall efficiency of the plant.

### Feedwater Pumps
Feedwater pumps send the preheated water back for reboiling in the steam generators. These pumps operate at high pressure and enable the feedwater to overcome the steam pressure in the boiling device.

### Feedwater Regulating Valves

The feedwater regulating valves control the flow of feedwater back to the boiling device, enabling operators to maintain a balance between feedwater flow and steam production.

## Circulating Water System

The circulating water system pumps cool water from an outside source into the condensers to condense steam. Water is pumped from an intake structure located on the source of water, through tubes in the condensers, and back to the outside water source, somewhat warmer than when it entered the plant.

At Millstone, Long Island Sound is the outside source. After the water flows through the condenser tubes, it flows into what was once the Millstone granite quarry and then into the Sound.

### Circulating Water Screens

Because sea water can carry debris that could clog the condenser tubes, the intakes are equipped with devices to clear debris from the water. Trash racks at the intake entrance prevent large debris, such as floating logs and large seaweed, from entering the plant. These racks are cleaned regularly.

Traveling screens filter smaller items, such as seaweed, fish and shellfish. The screens are made of wire mesh with 1/4 to 3/8 inch opening. When enough debris has accumulated on the screens, the screens are cleaned from behind by a pressure spray system.

### Circulating Water Pumps

Large circulating water pumps, located in the intake structure, pump cooling water through the condensers in the plant. Millstone 2 has two condensers with four pumps. Millstone 3 has three condensers with six pumps.

### Thermal Discharge

The circulating water discharged from the plant has been warmed by the process of condensing the steam. The temperature increase varies between the plants and is dependent upon power output, but is generally in the range of 20 to 40 degrees F. Because warm water has a potential for environmental impact, biological studies have been and continue to be conducted at the plants.

Studies at Millstone have demonstrated minimal environmental impact. Because of its location near the mouth of Long Island Sound, the tidal flow past Millstone is approximately thirty times greater than the flow through the two units. A measurable impact has been detected only in certain seaweed populations directly adjacent to the discharge.

## Shutdown Cooling System

When a reactor shuts down, the fuel retains a significant amount of heat even though the fission reaction itself has been stopped. The fuel also generates additional heat through the decay of fission products. Although the heat output is a small percentage of that of normal operating conditions, it is sufficient to require a means of heat removal. During a non-emergency shutdown, the reactor will be placed in either hot-standby or cold-shutdown, depending on the expected duration and the work to be done during the outage.

In hot-standby, the fission reaction is stopped by the insertion of control rods, but the reactor system is maintained at close to normal operating temperature and pressure by removing decay heat at the rate at which it is produced. This allows the plant to resume operation by restarting the fission process without the need to go through a lengthy system heat-up.

When the plant is going to be out of service for several days, or when it is shutting down for refueling, it will be taken to cold shutdown. Heat is removed more quickly than it is being produced, and the temperature of the reactor system is reduced to less than 200 degrees F and 200 psi. This allows for inspection and maintenance of system components.

### Shutdown Cooling

Steam bypasses the turbine-generator and goes directly to the condensers. This water is returned to the steam generators by the feedwater pumps. Additional cooling, however, is provided by initiating the auxiliary feedwater system. This system takes cool water from a large storage tank and pumps it into the steam generators. The water boils in the steam generators, and is then sent to the condenser or vented to the atmosphere. Because this water is coming form the secondary side of the steam generators, it is not radioactive.

If the plant is to taken to cold shutdown, the Residual Heat Removal (RHR) system is initiated when the primary system reaches 300 degrees F. Pumps in the RHR system take water from the primary system, cool it by sending through heat exchangers, and return the cooler water to the primary system. The pumps in this system are also used in the Low Pressure Safety Injection (LPSI) systems, described later in this section.

## Emergency Systems

Some safety systems are designed to provide additional water to the reactor in the event of a loss of its regular supply of coolant water. The objective of the Emergency Core Cooling System (ECCS) is to keep the core covered with water during the entire duration of the event. This prevents significant damage from overheating to the uranium pellets, as well as to the metal fuel rods that contain them.

Some safety systems and components are designed to provide a physical barrier to the release of radioactivity to the public regardless of conditions inside the plant. These are: 1) the containment building; 2) the reactor coolant system boundary; and 3) the fuel rod cladding, collectively referred to as the three fission product barriers.

Still other safety systems are designed to reduce/clean up the level of radioactivity in the event it is released to the reactor containment building system or leaks from it. These are the containment sprays, containment air recirculation, standby gas treatment systems, and enclosure building filtration system.

### Emergency Core Cooling System

The ECCS provides a backup water supply to the core in the event of a variety of Loss of Coolant Accidents (LOCAs) ranging from a small-break LOCA, in which a small pipe break exists but system pressure remains relatively high, to a large-break LOCA, in which a large pipe break causes a rapid loss of water and system pressure.

The components of the ECCS, like other safety systems, are redundant; that is, any component necessary to keep the core covered under any set of conditions has a backup. This is consistent with the "single failure criteria" design philosophy of the U.S. Nuclear Regulatory Commission (NRC) and the nuclear industry. This philosophy ensures that the public will not be endangered by the failure of a single piece of equipment necessary to mitigate the consequences of an accident.

The function of the ECCS in a PWR is to keep the core covered with water in the event of a LOCA. The reactor at a PWR would "scram" on a number of signals received as the result of a LOCA of any size, and various components of the ECCS would initiate. The systems of the ECCS all draw water with a high boron concentration designed to prevent the fission process from resuming.

Among the components of the ECCS are the charging pumps, high- pressure safety injection, low pressure safety injection, containment spray, water recirculation and accumulator tanks.

### Charging Pumps

In the event of a very small leak in the primary system of a PWR, the charging pumps (part of the plant's Chemical and Volume Control System) would supply makeup water to the system. These pumps are capable of injecting water at normal operating pressure, and will supply sufficient water to compensate for any leak too small to depressurize the system to the operating pressure of the high pressure safety injection system (HPSI), described below.

### High Pressure Safety Injection System (HPSI)

HPSI is designed to keep the core covered in the event of a small to intermediate break LOCA during which some primary system pressure is maintained and water loss is intermediate. HPSI consists of two pumps that pour borated water from a large refueling water storage tank (RWST), located outside the reactor building, into the reactor vessel. Its operating range varies from plant to plant, but is generally in the range of 600 to 1,700 psi.

### Low pressure Safety Injection System (LPSI)

The LPSI system is designed to provide large volumes of water to the core during a large break LOCA in which the primary system is rapidly depressurized and more water is being lost than can be replaced by the HPSI system. It operates at approximately 600 psi or less, and pours thousands of gallons of water per minute from the RWST into the reactor vessel.

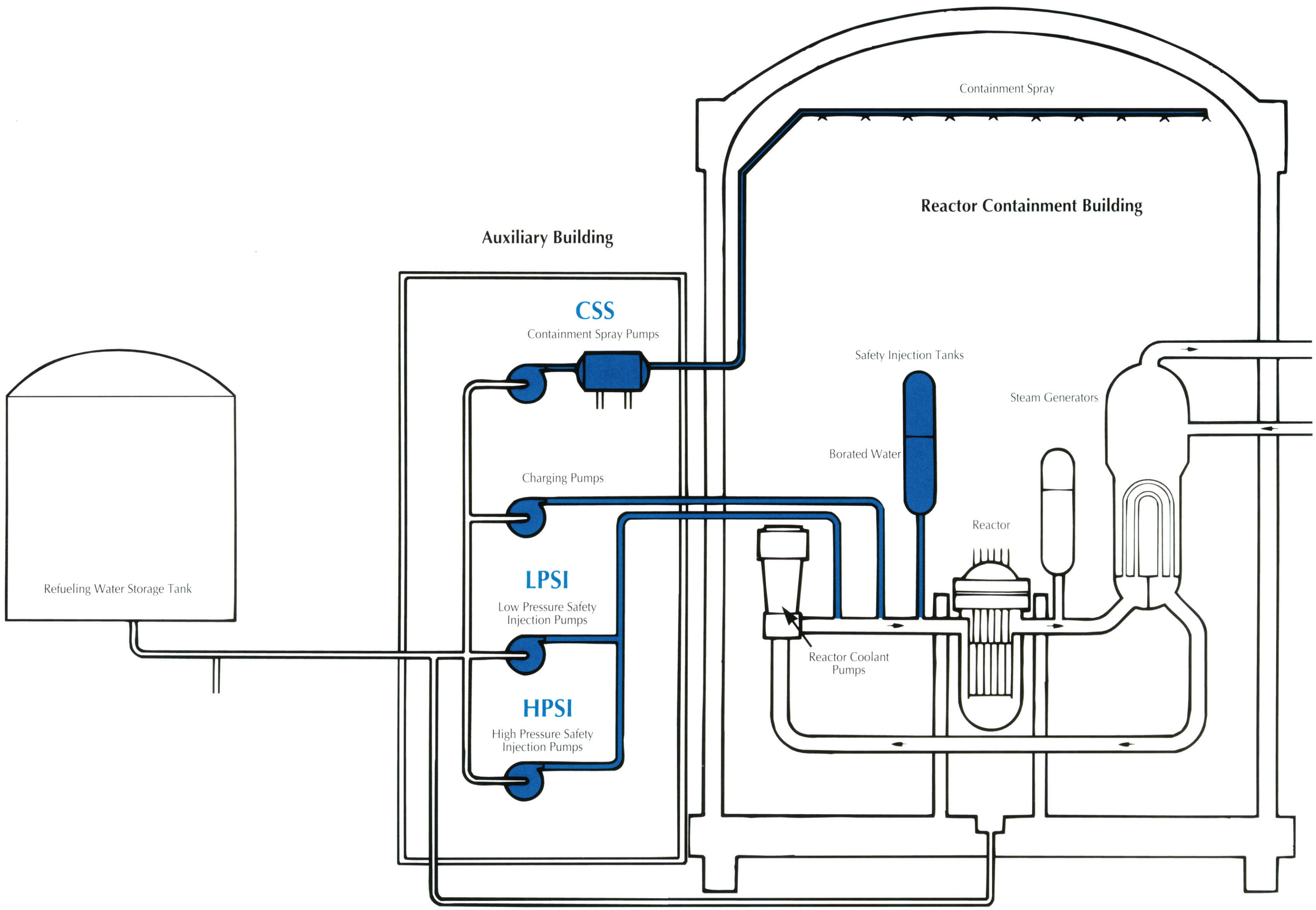
### Containment Spray System (CSS)

In the event of a LOCA, steam pressure in containment will increase, and the containment spray system may initiate. Pumps in this system will also take water from the RWST, and spray it into the containment atmosphere. The purpose of this system is to cool and condense steam in the containment, thus lowering pressure within the building. It also would remove some radioactive fission products from the containment atmosphere.

### Water Recirculation

The HPSI, LPSI and containment spray systems described above all use the RWST as their primary source of water. Obviously, this tank could eventually be depleted. At that point, or at any point deemed wise by plant operators, these systems can be aligned to take water that has accumulated on the floor of the containment and recycle it though heat exchangers. Thus these systems have a virtually inexhaustible supply of water.

# Emergency Core Cooling System



### Safety Injection or Accumulator Tanks

PWRs are equipped with safety injection tanks designed to cover the core during the early stages of a large break LOCA. These tanks contain borated water under a pressure of 225 to 650 psi. If primary system pressure drops below that level, the tanks automatically flood the core with thousands of gallons of water without the need for any pumps or other equipment.

## Physical Barriers

### Fuel Cladding

The fuel rods that contain the uranium pellets provide a barrier to fission product release. These rods, made of either stainless steel or a high-quality zirconium alloy, are pressurized with helium and sealed prior to being placed in the reactor. The cladding, usually about 0.025 inches thick, retains fission products produced on the outside surface of the pellets.

### Reactor Coolant System

The reactor coolant system acts as the second barrier to a fission product release. It consists of the reactor vessel itself and associated piping and equipment. The vessel is a high-quality carbon steel container, three to nine inches thick.

In a PWR, the entire primary coolant system is considered part of this barrier.

### Containment

The containment building is the final barrier designed to prevent the release of radioactivity from the reactor coolant system to the environment under both normal and the most severe emergency conditions. Therefore, all systems and components that could potentially release large amounts of radioactivity are housed in the containment structure.

Some PWRs, including Millstone 2 and 3, also have an enclosure building around the primary containment to contain leakage from the primary containment and treat it before release to the environment.

The containments are designed to withstand not only the internal forces generated by a severe accident, but also external forces, such as a tornado, hurricane, plane crash or earthquake.

## Electrical Transmission

Electricity coming from the main electrical generator is at a relatively low voltage (approximately 24,000 volts), but with a high current. This current cannot be carried by normal transmission lines without damaging the lines. Thus, it must be transformed to a form more suitable for distribution before leaving the station. The power is carried from the generator to the main transformer through a large hollow conducting pipe rather than transmission lines. This pipe, called the isolated phase bus (or isophase bus, for short), is enclosed within another pipe, and is air-cooled both inside and out to prevent damage to the conductor.

In the transformer yard, electricity from the isophase bus enters the main transformer, where it is transformed from 24,000 volts up to 345,000 volts. At this voltage, the current is low enough to be transmitted via transmission lines, and transmission losses are minimized. The main transformer is cooled by oil, which is itself cooled by a massive array of air fans.

### Station Power

Before the electricity enters the main transformer, a small percentage of it is "tapped off" by the normal station service transformer (NSST), where it is transformed from 24,000 volts to a lower voltage. This voltage varies from plant to plant, but is generally in the range of 4,000 to 7,000 volts.

The NSST is the source of electricity for plant equipment when the plant is in a normal operating mode (i.e., the generator is producing electricity). The plant uses approximately four to five percent of the electricity produced by the generator.

If the generator is not producing electricity, plant components get their power from the transmission grid, either through the main transformer and NSST or through the reserve station service transformer (RSST). This transformer takes electricity from the transmission grid and transforms it to 4,000 to 7,000 volts, suitable for "in-house" use.

### Emergency Power

If both the NSST and the RSST are ever unavailable, each plant has two redundant onsite sources of backup power to provide all the AC power necessary to handle emergency conditions. Either of the two onsite sources is capable of independently operating the plant's emergency systems. Millstone 2 and 3 have two diesel generators each.

### Loss of Normal Power

Loss of Normal Power is the unlikely condition during which all normal off-site and emergency on-site AC power sources are unavailable. Even under these conditions, the plant still has the capability of cooling down. Power to the controls necessary to operate equipment would be provided by the station's DC batteries.

Cooling is provided with the help of a phenomenon called "natural circulation." It makes use of the principle that warm water rises and cool water falls. Water heated in the reactor automatically flows upward to the steam generators. Heat is taken away by the secondary system water in the steam generator. The cooled water flows back downward to the reactor vessel.

In order to maintain the cooling process, however, the water on the secondary side of the steam generators, which boils as it draws heat away from the primary system, must be replenished. This is accomplished by using a steam-driven auxiliary feedwater pump, which takes water from the condensate storage tank and pours it into the steam generators. Because this pump is driven by steam rather than electricity, it can operate as long as sufficient heat is being produced in the reactor to generate steam.

## Control Room

All plant equipment is monitored and operated from the control room — the "nerve center" of the plant. Operators in the control room constantly monitor plant conditions, respond to changes in system parameters and, if necessary, will undertake actions to bring plant conditions under control.

The control building itself, because it is considered part of the emergency system, is constructed to Class I standards: it is capable of withstanding a severe earthquake.

The atmosphere of the control room is carefully controlled, and if a condition existed which made the air outside the control room unsafe, the control room would automatically be isolated. This would ensure that operators could remain in the room to bring any emergency situation under control.

### Control Room Operators

Operators at Dominion's nuclear plants come from a variety of technical backgrounds. The majority, however, have four or more years of experience operating a reactor in the nuclear Navy. As a Navy reactor operator, he or she has already received intensive training in mathematics, nuclear physics, reactor physics and chemistry, and has passed a rigorous written and oral examination prior to operation of the ship's reactor.

After joining Dominion with this background, a candidate undergoes intensive training before becoming a nuclear plant operator. He or she begins as a plant equipment operator (PEO), performing various tasks around the plant under the direction of the control room. In addition to this on-the-job training, the PEO receives classroom training in plant systems, theory of operation and other plant-related subject.

After one to two years, some PEO's will be selected for the license training program to become reactor operators. This program includes more than one thousand hours of instruction of plant systems design and operation. It typically involves: twenty weeks of classroom instruction in topics such as reactor theory, thermal hydraulics, and nuclear physics; ten weeks of training on a computer-controlled simulator, which provides an exact, working replica of the control room; and twelve weeks of on-the-job training under the direct supervision of a licensed reactor operator.

After this intensive program is completed, the reactor operator license exam is administered. The comprehensive exam consists of 3 parts:

- A six-hour written exam, with sections on reactor theory, plant systems, instrumentation, and procedures.
- An oral "walk-through" exam, in which an NRC examiner spends 4 to 6 hours with each candidate, asking questions on plant-related activities, equipment or procedures.
- A startup certification exam, where each candidate operates the computerized control room simulator under various conditions.
- After successful completion of this exam, a qualification certificate is issued and the individual is then allowed to operate the plant.

Although those who have reached this point are now reactor operators, training does not end. One week out of every six is spent in update training, and additional time is spent every year training on a simulator. They also must pass an annual re-qualification exam, administered by Dominion under the auspices of the NRC.

4

# Emergency Preparedness

Millstone Station, the State of Connecticut's Department of Emergency Management and Homeland Security (DEMHS), and the communities surrounding Millstone Station have developed comprehensive plans for responding to nuclear power plant emergencies. The objectives of these plans are to:

- assess plant conditions
- provide a support organization for bringing plant conditions under control and into recovery
- provide procedures and means for notification of federal, state, and local officials
- provide procedures for protecting the health and safety of the public by initiating necessary protective actions
- provide procedures and means for alert and notification of the public of protective action recommendations

In the event of a nuclear plant emergency, Millstone is responsible for determining its cause, assessing and classifying the severity of potential consequences, notifying government officials, and initiating actions to return the plant to a stable condition.

State and local officials are responsible for notifying the public and initiating actions, if necessary, to protect the health and safety of the public. These protective actions could include establishing access control of an affected area, controls of food, water, milk and livestock and sheltering or evacuation of the population in an affected area.

## Types Of Accidents

Nuclear power plants are equipped with systems that will protect the public under a variety of accident conditions. During design of the plant, a spectrum of postulated accident scenarios are analyzed, and the plant is fitted with redundant safety systems to prevent significant core damage and a large release of radioactivity under those conditions. These accidents range from low probability (1 in 10,000 per reactor per year) occurrences, such as a large pipe break Loss of Coolant Accident (LOCA), to a higher probability, but low consequence, occurrence such as an unplanned release of small amounts of radioactivity.

There are accidents whose probability of occurrence range from 1 in 10,000 per reactor per year to 1 in 10,000,000 per reactor per year and lower (plant lifetime is greater than 40 years with license extensions). These are called severe core damage accidents in which sequences of multiple, successive failures beyond the plant's design basis are postulated. These accidents result in damages ranging from damage to fuel cladding to core melting. The final line of defense for these types of low probability events would be the Emergency Plan.

## Emergency Planning Zones

Communities located within approximately 10 miles of a nuclear power plant comprise the plume Exposure Pathway Zone (EPZ). The U.S. Nuclear Regulatory Commission (NRC) considers the 10-mile EPZ as the area that could be affected by direct exposure to radiation in the event of a serious plant accident.

Additionally, communities within 50 miles of the plant make up the Ingestion Exposure Pathway Zone (IPZ). This is an area designated by the NRC as having the potential for exposure from ingestion of contaminated food or water.

## Incident Classification Levels

Nuclear plant operators will classify an incident according to a specific set of guidelines based upon plant conditions and potential off-site consequences. These guidelines, known as Emergency Action Levels, are specific to each nuclear unit and provide the information needed to determine the appropriate emergency classification level.

The emergency classification levels are prescribed by the NRC in conjunction with the Department of Homeland Security and the U.S. Environmental Protection Agency (EPA). The four emergency classification levels are:

### Unusual Event

An Unusual Event is the lowest of the four NRC emergency classification levels. It involves a minor problem at the plant and may result in a very small radiological release. The nuclear station, state and local emergency response organizations would not be activated and no protective actions for the public are required.

### Alert

An Alert is the second lowest of the four NRC emergency classification levels and involves a relatively minor event. A small release of radioactivity could occur. The nuclear station's emergency response organization would be activated. State and local response organizations would be monitoring the situation closely and key personnel would be activated or placed on standby. Usually, no protective actions are required.

### Site Area Emergency

A Site Area Emergency is the second highest of the four NRC emergency classification levels and involves a relatively serious problem at the plant. A small radioactive release is possible, however, the consequences would be limited to the plant's site boundary. The nuclear station, state and local emergency response organizations would be activated. Precautionary protective actions may be required for protection of the public such as monitoring food, water, milk and considering placing milk animals on stored feed.

### General Emergency

A General Emergency is the most serious of the four NRC emergency classification levels. It could involve serious damage to the plant's safety systems and may result in the release of radioactive materials to an area beyond the plant's boundaries. Protective actions for the public would be required.

# Incident Classification Levels

| Federal Incident Classification | CT Posture Code | Protective Action Decisions (PAD) Guidelines for Radiological Incidents<br>Millstone Power Station 10-Mile Emergency Planning Zone |
|---|---|---|
| Notification Of Unusual Event | Delta 1 | **Unusual occurrence. No unplanned release of radioactivity.**<br>No public protective actions required. |
| | Delta 2 | **Unusual occurrence with unplanned release of minute amounts of radioactivity.**<br>No public protective actions required. Possible standby for key staff. |
| Alert | Charlie 1 | **Actual or potential release of minute amounts of radioactivity.**<br><br>***State and Locals:*** Place key staff on standby. If appropriate, activate EOC.<br><br>***State:*** Bring EAS to standby status. Consider monitoring food, water, and milk pathways. Activate Transportation Staging Area (TSA). Place Host Communities on standby, as necessary. |
| Site Area Emergency | Charlie 2 | **Actual or potential release of limited amounts of radioactivity.**<br><br>***State and Locals:*** Activate EOC. Coordinate activation of public alerting siren system and EAS. Coordinate precautionary transfer of school children.<br><br>***State:*** Monitor food, water, and milk pathways. Place milk animals on stored feed, if necessary. If not done, activate Transportation Staging Area (TSA) and Host Communities. Close State parks. |
| General Emergency | Bravo | **Events with potential delayed release of relatively large amounts of radioactivity such as station blackout or loss of control room security.**<br><br>***State and Locals:*** Coordinate activation of public alerting siren system and EAS. EVACUATE Zone A and SHELTER Zones B, C, D, E and F.<br><br>***State:*** Control food, water and milk. Consider potassium iodide (KI)* recommendations for the public and emergency workers. |
| | Alpha | **Actual or potential release of large amounts of radioactivity. Actual or potential breach in containment.**<br><br>***State and Locals:*** Coordinate activation of public alerting siren system and EAS. EVACUATE Zones A and B. Take SHELTER in Zones C, D, E and F.<br><br>***State:*** Control food, water and milk. Consider potassium iodide (KI)* recommendations for the public and emergency workers. |

*KI is available at the Host Communities. 05/04

In addition to the emergency classification levels described, the State of Connecticut utilizes its own corresponding radiological incident classification scheme, known as posture codes. Posture codes, which are consistent with the federally mandated emergency classification levels, guide state and local officials with off-site public protective action recommendations

## Notification System

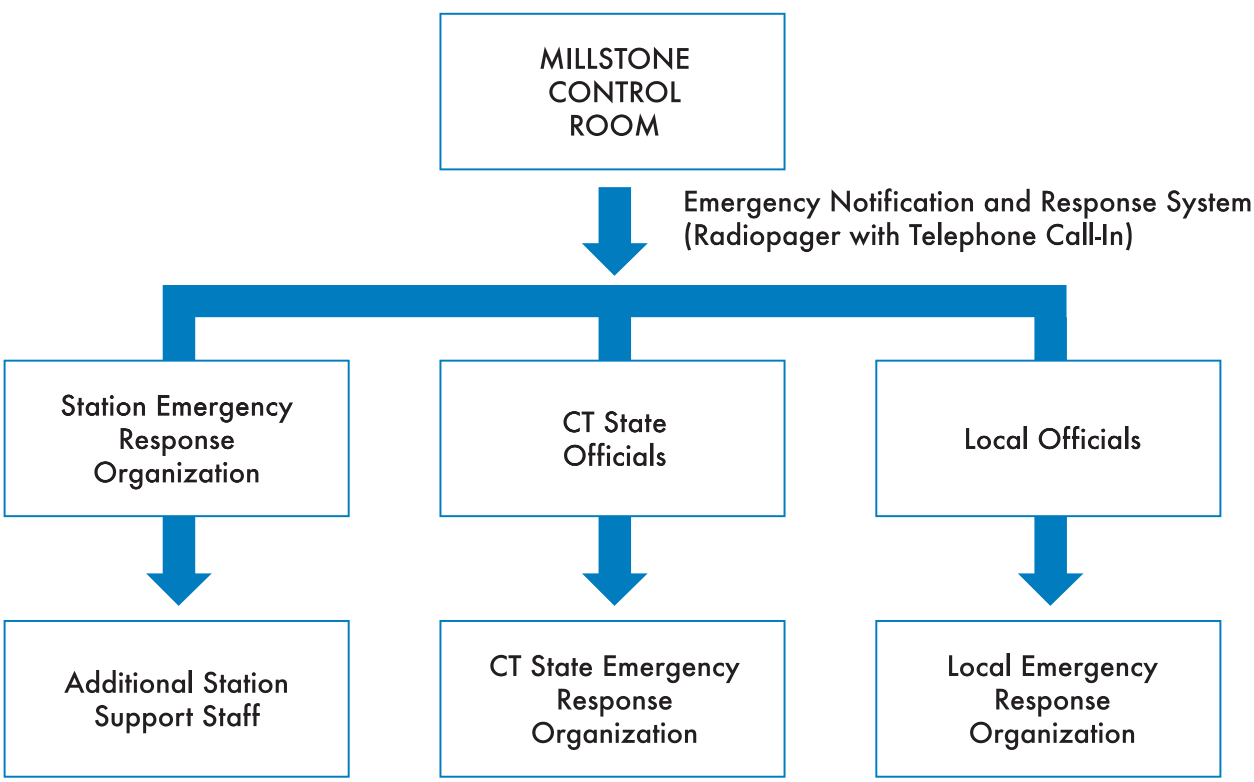
Within 15 minutes after classifying an incident, the Millstone Power Station must notify designated government officials. In Connecticut, this prompt notification is made to Connecticut and New York state officials and local officials (within the 10-mile EPZ) via a pager system, with additional details available through a telephone call back system and paper FAX Incident Report.

When an emergency is recognized and classified, assigned nuclear station, state, and local emergency responders are notified. Millstone members of the Station Emergency Response Organizations (SERO) are notified by the same pager system used to contact state and local officials.

If the emergency is classified as an UNUSUAL EVENT, on-site personnel and resources are sufficient to respond; therefore, plant, state, and local emergency response organizations are usually not activated. However, if the emergency is classified as an ALERT, the plant SERO is activated. State and local officials are not required to activate their emergency response organizations at the ALERT classification, but may do so if they choose. All station, state, and local emergency responders are activated at the SITE AREA EMERGENCY and GENERAL EMERGENCY classifications.

## CONNECTICUT NOTIFICATIONS

Alerting Public Officials and Emergency Response Organizations



### Public Alerting System (PAS)

Sirens alert the public to tune to their local Emergency Alert System (EAS) radio or television stations for emergency information or instructions to prepare the public in the event protective actions must be taken.

The sirens can be operated in a number of different modes:

- The alert signal is a steady tone lasting for three minutes, indicating a natural or man-made disaster, such as severe weather, chemical accidents, floods, or nuclear power plant accident
- A long wavering tone signals an enemy attack
- A short wavering tone signals a fire
- A public address mode allows for voice projection over a limited distance from a central control station, located in each community

Some communities that use the sirens for fire and other emergency notifications test the sirens on a routine basis.

In the event a siren fails, each community has the ability to notify those individuals through route alerting. Route alerting is when a public safety vehicle is dispatched to the area affected and provides the warning information through a public address system.

### Emergency Alert System (EAS)

The EAS is operated by each state's emergency management office in cooperation with selected radio and television stations. If an emergency results in an activation of the siren system, residents can tune in to a local participating EAS radio or television station for further details and instructions. Individual communities can also activate local sirens and EAS stations in the event of a local emergency.

## Emergency Information

### Media Emergency Information

In the event of an emergency, the media is an important method of providing information and instructions to the public. A joint Millstone and state Media Center will be established to provide timely, accurate and coordinated information in a setting designed to accommodate media needs. Briefings and news conferences with representatives from Dominion, state emergency agencies, and technical experts will be held as needed. Established telephone numbers will also be provided for inquiries from media representatives unable to go to the Media Center. News releases will be developed and FAXed to the media. (Directions to the Hartford Armory are provided at the back of the book).

### Public Emergency Information

Information and instructions concerning nuclear power plant emergencies are made available to the public on an ongoing basis. The yellow pages of the telephone directories for the communities located in the plume exposure pathway (10-mile) EPZ, contain emergency instructions and evacuation maps that can be used by both the resident and transient population. In addition, an emergency information planning book, containing background information and emergency instructions, is mailed to all residents and businesses in those same EPZ communities on a periodic basis.

Brochures or signs providing emergency information and instructions for visitors are also available at parks, beaches, and other recreation areas throughout the nuclear site's 10-mile EPZ. In addition, brochures containing emergency information and instructions for farmers, food processors, and food distributors located in the Ingestion Pathway (50-mile) Zone (IPZ) are available to the agricultural community.

## Public Protective Actions

Following activation of the emergency response organizations, state and local officials will issue appropriate public protective action directives. Depending on the nature of the incident, these could include:

- Precautionary closing of schools, beaches, and other recreational facilities
- Taking shelter
- Access Control
- Evacuation
- Food, water, milk and livestock feed control
- Ingestion of Potassium Iodide

In the event of an emergency, the initial plume exposure (10-mile) pathway precautionary action would likely be the precautionary closing of schools, beaches, parks and forests. These actions may be taken at an ALERT or SITE AREA EMERGENCY classification level if there were indications that plant conditions could deteriorate further.

In the event of a GENERAL EMERGENCY classification, protective actions would be directed for the public in potentially affected areas. Protective action directives could include evacuation and/or the sheltering of the public within a predetermined planning area of an approximate 2-mile, 5-mile, or 10-mile radius. Food water, milk and livestock feed control protective actions are planned within the ingestion pathway zone (50-mile) IPZ. These are relatively longer-term actions taken after the plume phase EPZ actions are accomplished.

If an evacuation is necessary, reception centers in host communities will be available to receive members of the public who require temporary shelter, relocation with family or friends, or other assistance. The host communities and their designated reception centers are located outside the plume exposure pathway EPZ for Millstone Power Station.

Precautionary dismissals for schools may precede public evacuation in many towns where schools fall within the 10-mile EPZ.

## Host Community Reception Centers

| EPZ Community | Host Community | Reception Center |
|---|---|---|
| East Lyme, CT | New Haven, CT | Southern CT State University |
| Fishers Island, NY | Windham, CT | Windham High School |
| Groton City, CT | Norwich, CT | Kelly Middle School |
| Groton Town, CT | Norwich, CT | Kelly Middle School |
| Ledyard, CT | Storrs, CT | University of Connecticut |
| Lyme, CT | New Haven, CT | Southern CT State University |
| Montville, CT | East Hartford, CT | East Hartford High School |
| New London, CT | Windham, CT | Windham High School |
| Old Lyme, CT | New Haven, CT | Southern CT State University |
| Waterford, CT | East Hartford, CT | East Hartford High School |

Host Communities are located more than 15 miles from the power station.

## Emergency Response Facilities

### Millstone Control Rooms

Each nuclear unit has a Control Room, where plant conditions are monitored and controlled and where corrective actions would be taken to return the plant to a safe and stable condition in an emergency. The Control Room is the source of key communications to other on-site and off-site emergency response personnel and facilities, including transmitting plant data, incident reports and long- and short-term corrective actions. All nuclear station Control Rooms are shielded and have controlled ventilation systems so that they can remain habitable even in the event of a significant release of radioactive material. They are located immediately adjacent to their respective plants.

### Millstone Emergency Operations Facility (EOF)

The nuclear station's EOF is the primary center for the management of the station's emergency response, coordination of radiological and environmental assessments, and exchange of information among the station, state, and federal emergency response organizations. The EOF contains communication links to on-site data and off-site organizations. EOF functions include linking Dominion to the state Emergency Operations Centers and the Media Center, deploying off-site radiological field teams, collating field team data, performing off-site dose assessment functions, and providing protective action recommendations to the State.

The EOF at Millstone is located about 1 mile north of the station. Because of the proximity to the plant, the Millstone EOF also has shielding and a controlled ventilation system.

### Millstone Technical Support Center (TSC)

Millstone station's TSC is an emergency operations work center where designated engineering and technical personnel can analyze plant conditions to predict trends and devise appropriate corrective actions. The TSC's facilities provide data to evaluate station conditions so corrective actions can be developed to mitigate the event. There is also a technical reference library with drawings, procedures and systems descriptions. The TSC is located in a dedicated building near the Unit 3 turbine building.

### Millstone Operational Support Center (OSC)

Millstone's OSC is the assembly point for support personnel who perform on-site assessment, repair, and search and rescue tasks in an emergency. The OSC also provides a staging area for personnel who are deployed into on-site areas. At Millstone, the affected unit OSC manager and assistants are located in the TSC building.

### State Emergency Operations Center (EOC)

The State's EOC provides an established place for the off-site emergency response organization. The EOC will be staffed by key state and local agencies required for a radiological emergency (state police, health and safety, environmental protection, etc.) Overall coordination is provided by state emergency management officials. Regional emergency management offices in the state provide direct contact with local agencies and implement state EOC directives. Once the Governor declares a "state of emergency," the Governor directs and assumes responsibility of the emergency response efforts. The state EOC and regional offices are also places where local officials may request manpower and additional resources.

The State of Connecticut EOC is located in the State Armory at 360 Broad Street, Hartford. The CT DEMHS Area 2 office, covering south central Connecticut, is located at the Department of Public Safety Office, Middletown. The CT DEMHS Area 3 office, covering north central Connecticut, is located at the Veteran's Home and Hospital, Rocky Hill. The CT DEMHS Area 4 office, covering eastern Connecticut, is located at the State Police Barracks, Colchester.

### Local Community Emergency Operations Centers

Each community within the 10-mile EPZ has its own Emergency Operations Center. Each local EOC is a communication point within each community, as well as a link with adjacent communities and the state. Each local chief executive, working with state and regional emergency officials, can direct protective actions for the community. Besides functioning as a briefing location for agency heads and emergency workers, the local EOC serves as a resource allocation facility and provides a central location where community officials can track emergency events and weather conditions.

### Joint Media Center

In order for Dominion and the State of Connecticut to meet its commitment to provide timely and accurate information, a joint state and Millstone Media Center will be activated in the event of any potentially significant emergency (usually an ALERT classification or higher) that occurs at Millstone. The Media Center is the central coordination point where information about an emergency and the emergency response will be released to representatives of the news media. It is intended that the Media Center serve as the only media contact point for the state and Dominion during a radiological emergency.

The joint Media Center is located adjacent to the state EOC, at the State Armory at 360 Broad Street, Hartford, Connecticut. Directions to the Joint Media Center are provided at the end of this manual.

### Millstone Station Emergency Response Organization (SERO)

Millstone's emergency response organization is designed to support and complement the station on-shift organization. In addition, the Station Emergency Response Organization (SERO) interfaces with state and federal officials and provides information to the media. The goal of the site emergency organization is to activate within 60 minutes of an emergency declaration, with somewhat more time allowed for activation of the Media Center located at some distance from the plant site.

In the initial few minutes after classification of an emergency, the Shift Manager in the plant's Control Room assumes the duties of director of the emergency response until the Emergency Operations Facility is activated and the duties are assumed by a SERO emergency director.

The SERO emergency director is responsible for directing all emergency operations at the affected station, including classification, mitigation of the incident, and corporate communications. At Millstone the SERO emergency director is known as the Director of the Station Emergency Organization (DSEO).

Major functions of the SERO include:

- Implementing emergency operations procedures
- Providing technical support to recommend corrective actions
- Coordinating on-site radiation protection, sampling and dose assessment
- Performing off-site dose assessments
- Providing on-site resource needs, including manpower, equipment and supplies
- Maintaining site security
- Providing information to the public via the media

### State Emergency Response Organization

The Governor of Connecticut is responsible for directing the actions of all of the respective state agencies. The governor may direct state agencies to assist communities in order to ensure an adequate response to a radiological incident and protection of public health and safety.

The Department of Emergency Management and Homeland Security (DEMHS) in Connecticut operates the State's EOC. DEMHS directs the activities of participating state agencies in an emergency and coordinates services, materials and support to towns to ensure implementation of protective actions. The DEMHS is responsible for initiating the release of Emergency Alert System information to radio and television.

Numerous other state agencies may be involved with the emergency response, such as public safety, health services, agriculture, transportation, consumer protection, etc. For example, the Department of Environmental Protection provides emergency responses ranging from determining radiological impact to recommending protective actions.  Whereas the Department of Transportation and the Connecticut State Police provide traffic control and assisting in an evacuation. The State has an emergency plan that provides written procedures for each participating agency.

## Local Emergency Response Organizations

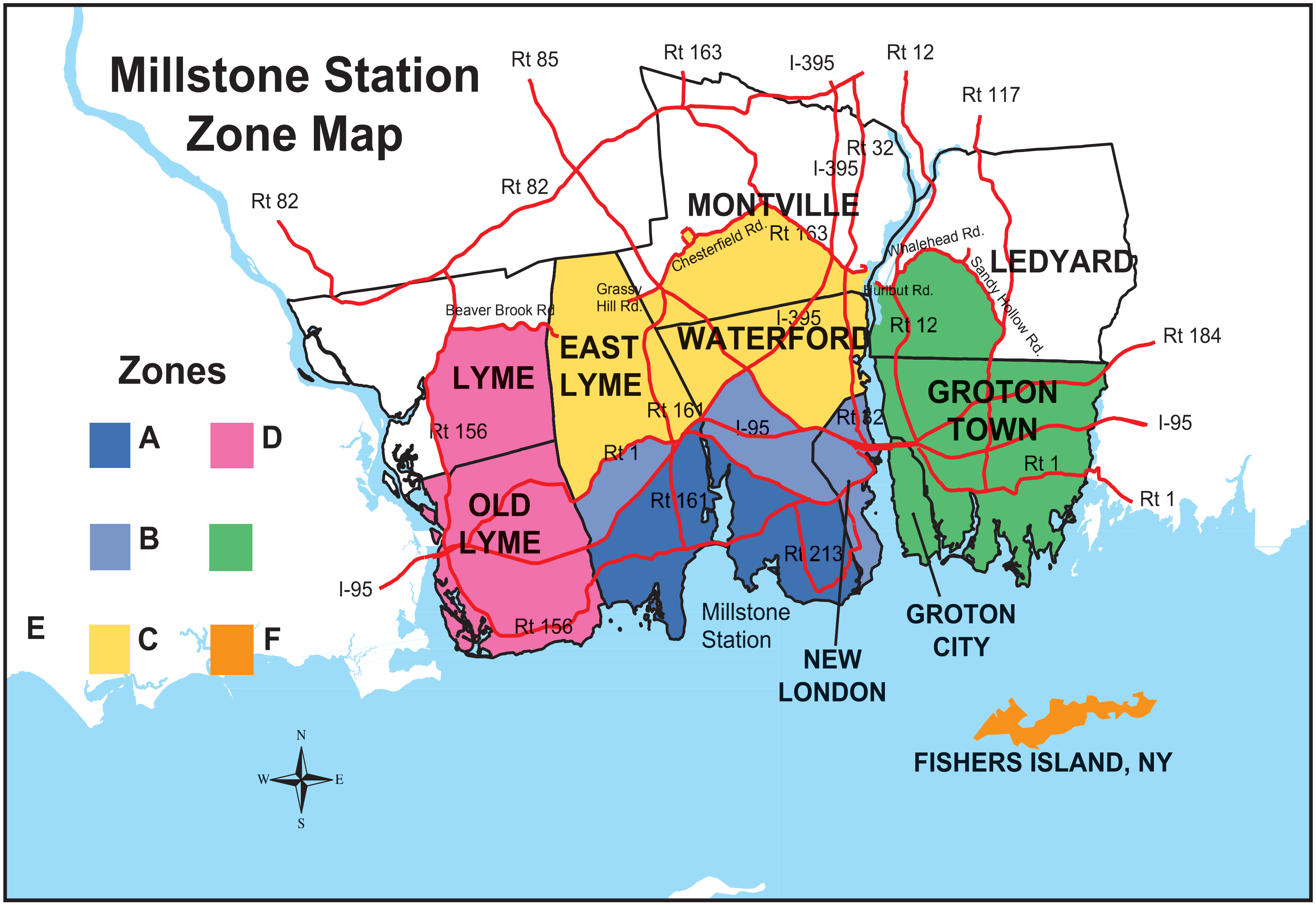
Each community within the 10-mile EPZ has its own Emergency Operations Center. These local EOCs are a communication point within each community, as well as a link with adjacent communities and the state. The local Chief Executive Officer designates an Emergency Management Director to carry out emergency plans. Each local chief executive, working with state and regional emergency officials, can direct protective actions for the community. Besides functioning as a briefing location for agency heads and emergency workers, the local EOC serves as a resource allocation facility and provides a central location where community officials can track emergency events and weather conditions.

## Federal Support Agencies

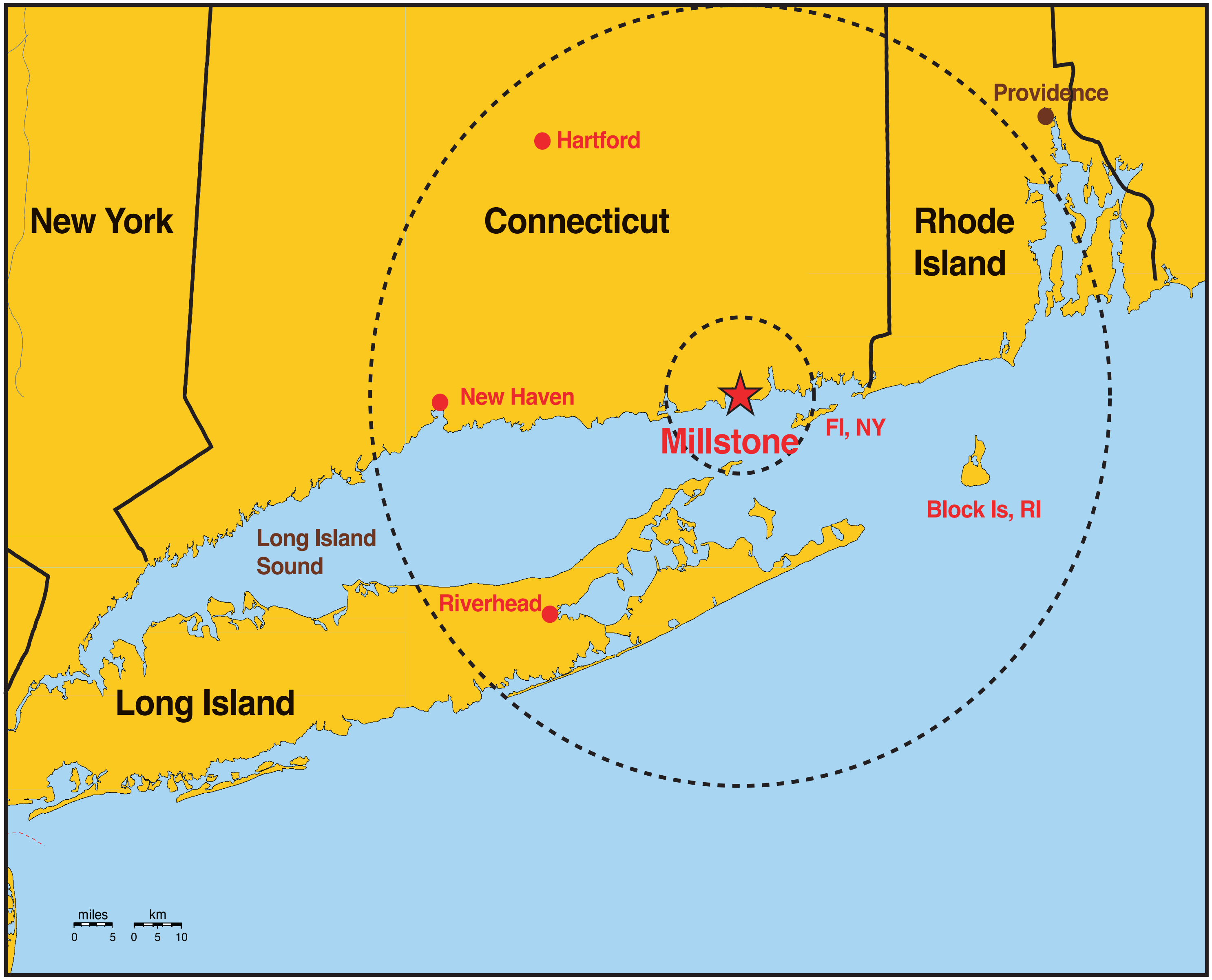
Other federal, state, local and private agencies may provide support in the event of a nuclear power plant emergency. The U.S. Nuclear Regulatory Commission (NRC) monitors nuclear plants, does an independent assessment of the emergency situation and offers regulatory guidance. The Department of Homeland Security provides support to state emergency management agencies and, along with the NRC, coordinates the activities of all federal agencies responding per the Federal Radiological Emergency Response Plan (FRERP).

Examples of other agencies that may assist in the emergency response include the U.S. Coast Guard, who provides access control and limited public notification along coastal waterways; AMTRAK, who directs train traffic in affected areas; the Institute of Nuclear Power Operations (INPO), who can acquire support and resources from other utilities as requested by Dominion; and the American Red Cross, who assists in social services through local and state agencies.

# 10-Mile Millstone Station Emergency Planning Zone Map



## 50-Mile Millstone Station Ingestion Planning Zone Map



# 5

# Nuclear Plant Security

## Regulated by the Federal Government

The nuclear energy industry is one of the few industries whose security program is regulated by the federal government. Nuclear plants must meet all federal security requirements, as determined and monitored by the U.S. Nuclear Regulatory Commission. On-site NRC security requirements are based on protecting the public from the possibility of exposure to radioactive releases caused by acts of sabotage. Intelligence information and incidents around the world are analyzed to ensure plant protection regulations are updated to reflect potential threats.

## Design Basis Threat

The NRC's "design basis threat" is the criterion nuclear plants use to develop defensive response strategies that cover a variety of situations. The NRC's design basis threat" is a definition of the threat against which nuclear plants must provide protection. The NRC determines the design basis threat according to technical studies and information received from intelligence experts and federal law enforcement agencies. It is reviewed by the agency twice a year. Since September 11, 2001, the NRC has twice increased the characteristics for the design basis threat–increasing the number of possible attackers and their weapons capabilities–raising the level against which nuclear plants must provide protection. Plant protection capabilities and response strategies are protected from public disclosure to avoid possible benefit of a potential adversary.

## Security Regulations

The NRC's security regulations ensure that the industry's security force can protect against a ground-based threat. The treat against which the industry must defend is characterized as a suicidal, well-trained paramilitary force, armed with automatic weapons and explosives, and intent on forcing its way into a nuclear power plant to commit radiological sabotage. Such a force may have the assistance of an "insider", who could pass along information and help the attackers. The presumed goal of such an attack would be the release of radioactive material from the plant.

Because of the industry's security programs and the defense in depth safety strategy, the U.S. Federal Bureau of Investigation classifies nuclear power plants as difficult targets.

Reference: Nuclear Energy Institute, copyright 2006

# 6

## Glossary Of Nuclear And Electrical Power Terms

**Access Control**
The prevention of unauthorized entry into an area using road barriers and traffic control. The area may include all or part of the Plume Exposure EPZ, or a specific Restricted Area that may be contaminated.

**Activation**
The process of making an emergency facility operational, requiring equipment set up and checking as well as having emergency response personnel assembled and ready to assume duties.

**Air Ejector**
A device that removes air from a condenser for the purpose of maintaining condenser vacuum.

**ALARA**
An industry-wide effort to reduce worker exposure. ALARA stands for "As Low As Reasonably Achievable."

**ALERT**
The Second lowest level of emergency classification.

**Alpha Particle**
A positively charged particle (2 protons and 2 neutrons) emitted from the nucleus of an atom during radioactive decay. Alpha particles can be stopped by a sheet of paper.

**Anticipated Transient Without Scram (ATWS)**
A deviation from normal operations during which the plant would normally shut down automatically, but fails to do so.

**Atom**
The smallest part of an element that has all the chemical properties of that element. Atoms are make up of protons, neutrons and electrons.

**Auxiliary Building**
A building which houses the service equipment necessary for the normal operation of a nuclear plant.

**Auxiliary Feedwater**
A backup feedwater supply used during plant startup and shutdown.

**Background Radiation**
The radiation in the natural environment, including cosmic rays and radiation from naturally radioactive material in air, water, the ground and living things.

**Backwash**
The procedure to clean the condensers by cycling water through one condenser waterbox and back through the other waterbox.

**Baseload Electricity**
Electricity from plants operated 24 hours a day (usually larger plants and those which produce the least expensive power). This contrasts with peak-load electricity, which is used to meet needs during times of greatest usage.

**Bequerel (symbol: Bq)**
A unit to describe a quantity of radioactive material. A Bq is the amount of material which will undergo one disintegration (decay) per second.

**Beta Particle**
A negatively charged particle (1 electron) emitted from the nucleus of an atom during radioactive decay. A beta particle can be stopped by an inch of wood or a thin sheet of aluminum.

**Blowdown**
The process of tapping water off the bottom of the secondary side of a steam generator to prevent accumulation of deposited material.

**Boiling Water Reactor (BWR)**
A light water nuclear reactor in which the water boils in the reactor vessel; the resulting steam drives a turbine to generate electricity.

**Boron**
An element which absorbs neutron radiation and is used in nuclear reactors to control the rate of fission. Boron is used in control rods and is also dissolved in the cooking water of PWRs.

**Breeder Reactor**
A reactor that produces fissionable fuel while consuming it, generating more fuel that it consumes.

**Capacity Factor**
The actual amount of electricity produced by a plant over a specified period of time (usually a year), expressed as a percentage of what the plant could have produced had it operated at full power, 24 hours a day, over that period of time.

**Cerenkov Radiation**
The light produced by charged atomic particles moving through a transparent medium at a speed greater than that of light in that medium. An example is the blue light emitted underwater by spent fuel during refueling and initial storage.

**Chain Reaction**
Also know as fission; a self-sustaining series of events that occurs when a neutron splits an atom and releases other neutrons at least one of which splits another atom, releasing additional neutrons.

**Charging Pump**
A low volume, high pressure pump that supplies makeup water to the reactor coolant system during normal operations, and serves as a safety injection pump for a small-break LOCA, which does not require high volumes of water.

**Chemical Addition Tank**
A tank containing boric acid, which is added to the reactor coolant system of a PWR for reactor control.

**Chemical and Volume Control System**
A PWR system that provides the reactor coolant system with the proper amount of boric acid for reactor control, maintains system water volume, and cleans the water using ion exchange resins.

**Circulating Water System**
The system that provides cooling water to the turbine-generator condensers to condense exhaust steam.

**Cladding**
The outer covering, usually stainless steel or zircaloy (a zirconium alloy) in which the nuclear fuel is sealed. The cladding serves as a barrier by preventing the release of radioactivity from the fuel into the coolant.

**Coastdown**
A gradual decrease in reactor power that occurs at the end of a fuel cycle, as the fuel becomes depleted.

**Cold Leg**
The piping in a PWR that carries cooled reactor coolant from the reactor coolant pump back to the reactor vessel.

**Cold Shutdown**
A reactor condition in which all control rods have been inserted and coolant temperature is below 200 degrees F. Also know as Mode 5 in a PWR.

**Condensate**
Water produced by the cooling of steam in a condenser.

**Condensate Storage Tank**
A tank that stores pure water for condensate makeup when a plant is operating, for steam generator makeup in a PWR to cool down following a reactor trip, and, in a BWR, for an emergency water supply during a LOCA.

**Condenser**
The heat exchanger that condenses exhaust steam from the low-pressure turbine back into water.

**Congregate Care**
The supportive action that includes the provision of food, shelter, routine medical services, and other essential provisions or services for evacuees.

**Containment**
The airtight steel and reinforced concrete structure around a reactor to confine fission products that might otherwise be released to the atmosphere in the event of a severe accident.

**Containment Air Recirculation (CAR) System**
A system that removes heat and radioactive materials from the containment atmosphere in the event of an accident.

**Containment Isolation**
The closing off of all possible pathways for air to escape from the containment.

**Containment Spray System**
A system which sprays cool water into the containment in the event of a containment pressurization event. The system condenses steam in the building to decrease pressure and remove radionuclides from the containment atmosphere.

**Contamination**
The deposition of unwanted radioactive material on the surface of structures, areas, objects, or people.

**Controlled Shutdown**
A procedure to take a plant slowly from a certain power level to shutdown.

**Control Rod**
A rod, plate or tube in a reactor containing a material that readily absorbs neutrons. Control rods prevent the neutrons from causing further fission and continuing the chain reaction.

**Control Room**
The operation center of a nuclear power plant where the plant can be monitored and controlled.

**Coolant**
A fluid, usually water, used to cool a nuclear reactor and transfer heat energy. In a light water reactor, the water also moderates, or slows down, neutrons so they will be able to cause fission.

**Core**
The fuel assemblies of a nuclear reactor where heat is produced.

**Core Spray System**
An emergency system in a BWR that sprays cooling water directly onto fuel assemblies in the event of a LOCA.

**Cosmic Rays**
Very high energy radiation of various sorts (mostly protons), originating beyond the earth's atmosphere. Cosmic rays are part of natural background radiation.

**Criticality**
The point at which a reactor is sustaining a chain reaction.

**Critical Mass**
The smallest amount of fuel necessary to sustain a chain reaction.

**Crossover Leg**
The piping in a PWR that carries cooled reactor coolant from the steam generator to the reactor coolant pump.

**Curie – (symbol: Ci)**
A unit to describe a quantity of radioactive material. A Ci is the amount of material which will disintegrate (decay) 37 billion times per second, approximately the rate of decay of one gram of radium.

**Decay Heat**
The heat produced in a reactor by radioactive atoms after the reactor has been shut down.

**Decay, Radioactive**
The process of unstable elements giving off their excess energy in the from of radiation in an attempt to reach a stable (non-radioactive) state.

**Decontamination**
The removal of radioactive contaminants by cleaning or washing with chemicals.

**Derate**
To decrease the authorized electrical output at a plant.

**Design Basis Accident (DBA)**
A postulated accident that serves as the basis for the design of safety systems and features in a nuclear power plant.

**Detensioning**
The process of loosening the studs that fasten the reactor vessel head to the reactor vessel.

**Diesel Generator**
An electrical generator used to operate plant safety systems in the event offsite power is not available.

**Discharge**
The warmed circulating water exiting a power plant.

**Disintegration – See "Decay, Radioactive"**

**Dose**
The quantity of energy absorbed from ionization per unit mass of tissue, usually measured in Rads.

**Dose Rate**
The absorbed dose delivered per unit time (for example: rads/hour)

**Dosimeter**
A device, such as a pocket ionization chamber or thermoluminescent dosimeter (TLD), which can be worn and used to measure and record the radiation dose a person receives over a period of time.

**Drywell**
Part of the primary containment in a BWR.

**Electron**
A subatomic particle with a mass equal to 1/1837 that of a proton.

**Emergency Alert System (EAS)**
The radio and television stations that provide a direct link between responsible authorities and the public, broadcasting emergency instructions and information.

**Emergency Classification**
The level scheme used to indicate an emergency's severity. The four levels, in increasing severity, are: Unusual Event, Alert, Site Area Emergency, and General Emergency.

**Emergency Core Cooling System (ECCS)**
A series of backup safety systems designed to pump sufficient cooling water into the reactor to keep the fuel under water in the event of an accident.

**Emergency Operations Center (EOC)**
The location(s) designated as the central command and control point for either the state or local Emergency Response Organization.

**Emergency Operations Facility (EOF)**
A facility operated by the nuclear plant site for evaluating and controlling emergency situations and coordinating emergency response.

**Emergency Planning Zone (EPZ)**
An area around a nuclear plant site for which planning has been done to ensure that prompt and effective actions can be taken to protect the public in the event of a radiological incident. The Plume Exposure Pathway EPZ is the area within a 10-mile radius of the site, while the Ingestion Exposure Pathway EPZ is the area within a 50-mile radius.

**Emergency Response Organization (ERO)**
Utility, federal, state, local, and private agency organizations designed to provide capabilities to implement emergency responses.

**Emergency Service Water System**
A system that provides cooling water to safety systems in the event of an accident.

**Emergency Station Service Transformer**
A transformer that provides backup electrical power for a plant from offsite in the event of a loss of other offsite sources.

**Emergency Worker Facility**
A facility where emergency workers are monitored for radioactive contamination and, if necessary, decontaminated.

**Enclosure Building**
The buildings surrounding the containments at Millstone 2 and 3. Kept slightly below atmospheric pressure, they serves as a secondary containment. The Millstone 1 containment system is also surrounded by a secondary containment called the reactor building.

**Enriched Fuel**
Uranium which has been modified by increasing the concentration of the fissionable isotope, Uranium-235, to be better able to sustain a chain reaction.

**Evacuation Time Estimate (ETE)**
A study of the roadway travel time required to leave the Plume Exposure Pathway EPZ.

**Exposure**
The absorption of external radiation or the ingestion of radioactive material.

**Extraction Steam**
The steam taken from certain stages of the turbines and the moisture separator/reheater, which is used to reheat the feedwater.

**Feedwater**
Water that is pumped into the boiler of a power plant to produce steam. In a BWR, feedwater is pumped into the reactor; in a PWR, it is pumped into the steam generator.

**Feedwater Coolant Injection System (FWCI)**
In a BWR, the means of providing high pressure safety injection in the event of a small-break LOCA. The system uses portions of the regular feedwater system and water from the Condensate Storage Tank.

**Feedwater Heaters**
The heat exchangers that reheat condensate prior to its return to the steam generator in a PWR or the reactor in a BWR. The heat source is the extraction steam system.

**Fission**
The splitting of a heavy atom's nucleus into two parts (creating the nuclei of two lighter atoms), accompanied by the release of a large amount of energy and one or more neutrons.

**Fission Products**
The atoms formed when uranium is split in a nuclear reaction. Most fission products are radioactive.

**Flux**
A measure of the number of neutrons passing through a certain cross-section of the reactor during a given period of time, used to measure the intensity of the fission reaction.

**Food Chain**
The pathways by which any material (including radioactive material) passes from the first absorbing organism through plants and animals to people.

**Fossil Fuels**
Coal, oil or natural gas, which are the remains of plants and animals that lived on earth millions of years ago.

**Fuel Assembly**
Fuel rods are arranged in assemblies which are placed in the reactor vessel to form the core. Each fuel assembly may contain from approximately 60 to 300 fuel rods.

**Fuel Pellets**
The uranium fuel in the form of ceramic cylinders about one-half inch long and three- eighths inch in diameter. They are stacked in long tubes to form fuel rods.

**Fuel Reprocessing**
The chemical processing of used reactor fuel to separate the fuel into waster products, and reusable uranium and plutonium.

**Fuel Rod**
A cylindrical rod, 10 to 14 feet long and usually made of stainless steel or zircaloy, filled with fuel pellets.

**Gamma Rays**
High-energy, short-wavelength highly penetrating electromagnetic radiation, similar to x-rays except they are emitted from the nucleus of an atom. Gamma rays are best shielded by dense materials, such as lead, water or concrete.

**Gas Turbine**
A backup emergency electrical generator that burns jet fuel to generate electricity.

**Geiger (Mueller) Counter**
An instrument for detecting and measuring beta and gamma radiation.

**General Emergency**
The highest of the four emergency classifications.

**Gray – (symbol: Gy)**
A unit of dose that measures the amount of energy absorbed from ionizing radiation per gram of absorbing material. It is 100 times larger than a rad.

**Half-Life**
The amount of time in which half of the unstable atoms in a particular radioactive substance will disintegrate. Each radioactive material has its own unique identifiable half-life, which can vary from a fraction of a second to billions of years.

**Health Physics (HP)**
The science concerned with recognition, evaluation and control of health hazards from ionizing radiation to protect workers and the public from adverse effects from the use of radiation or radioactive materials.

**Heat Exchanger**
A device, such as a steam generator or feedwater heater, that transfers heat from one material to another without direct contact between the two.

**High Pressure Safety Injection (HPSI)**
A safety system designed to provide small quantities of high pressure water to keep the fuel in the reactor covered in the event of a small-break LOCA.

**High Pressure Turbine**

A component that receives high pressure steam (800-1000 psi) from the boiler and converts the heat energy to rotational (kinetic) energy.

**Hot Shutdown**
A reactor condition in which the reactor is shut down, and reactor coolant system temperature is kept between 200-350 degrees F. Also known as Mode 4 in a PWR.

**Hot Standby**
A reactor condition in which the reactor is shut down, but reactor coolant system temperature and pressure are kept at or near normal levels. Also known as Mode 3 in a PWR.

**Hydrogen Recombiner**
A device which combines hydrogen with oxygen to form water. In this manner, a hydrogen recombiner is able to separate hydrogen from other gases.

**Incore Instrumentation**
Instruments located in the reactor core that monitor core temperature, fuel burnup and power level.

**Ingestion Pathway EPZ**
For planning purposes, the area within approximately a 50-mile radius of a nuclear plant site where the principal exposure in the event of an accident would be from the ingestion of contaminated water or food.

**Intake Structure**
The building located on an external body of water that houses the circulating water and service water intakes and pumps.

**Ion**
An electrically charged atom or molecule.

**Ion Exchange**
A chemical process involving the reversible interchange of ions between a solution and a solid material; used to purify water in various systems.

**Ionizing Radiation**
A relatively high energy radiation capable of displacing elections from atoms or molecules, forming ions. Examples include alpha, beta, neutron and gamma.

**ISFSI-Independent Spent Fuel Storage Installation**
Dry cask storage outside spent fuel pool allows for retrieval of fuel and subsequent shipment of spent fuel to a permanent government storage facility.

**Isotope**
Different forms of the same chemical element with the same chemical properties which are distinguished by having different numbers of neutrons in the nucleus. A single element may have many isotopes.

**Joint Media Center – See "Media Center"**

**Kilo – (symbol: k)**
A prefix meaning one thousand (for example: kilowatt).

**Light Water Reactor (LWR)**
A reactor that uses normal water as a coolant and a moderator, Most U.S. nuclear plants are LWRs.

**Limiting Condition For Operation**
A condition, such as the inoperability of one train of a safety system, under which a plant has a specified period of time to correct the condition or be shut down.

**LOCA (Loss of Coolant Accident)**
An accident involving a broken pipe or a stuck-open valve, resulting in a loss of coolant to the reactor. In the event of a LOCA, the reactor would shut down automatically and the emergency core cooling system would supply water to cool the core.

**Low Pressure Coolant/Safety Injection (LPCI/LPSI)**
A safety system designed to pump large volumes of low pressure water to keep the fuel in the reactor covered in the event of a large-break LOCA.

**Main Steam Isolation Valve (MSIV)**
A valve designed to stop the flow of steam in the event of a downstream main steam line break. They are located between the steam generator and the turbine in a PWR.

**Media Center**
A facility operated by the power station or the state for the coordinated release of information to the public via the news media by power station and off-site authorities.

**Mega – (symbol: M)**
A prefix meaning one million (for example: megawatt).

**Meltdown**
A buildup of heat in the core caused by insufficient cooling, resulting in melting of the fuel.

**Micro – (symbol: $\mu$)**
A prefix meaning one millionth (for example: microcurie).

**Milli – (symbol: m)**
A prefix meaning one thousandth (for example: millirem).

**Moderator**
A substance that slows down the neutrons in the core, allowing the neutrons to initiate fission and continue the chain reaction. Most U.S. plants use water as the moderator.

**Modes**
The categories of reactor conditions which describe the power levels and reactor coolant temperatures and pressures for a PWR. The modes consist of:
(1) power operation
(2) startup
(3) hot standby,
(4) hot shutdown,
(5) cold shutdown
(6) refueling

**Moisture Separator/Reheater**
A component that separates the moisture from the steam exiting the high-pressure turbine, then reheats the steam prior to it being sent to the low-pressure turbine.

**MS-l Hospital**
A designation granted to hospitals that are trained and capable of treating any individuals who suffer from substantial radiation-related injuries, or have been exposed to and contaminated by radioactive materials.

**Nano – (symbol: n)**
A prefix meaning one billionth (for example: nanocurie).

**Natural Background Radiation - See "Background Radiation"**

**Neutron**
An uncharged subatomic particle with a slightly greater mass than a proton and found in the nucleus of every atom heavier than hydrogen. Neutrons sustain the fission reaction in a nuclear reactor.

**Noble Gases**
Gases, some of which are common fission products, that do not combine chemically with other materials. If inhaled, they are immediately exhaled without being taken into the bloodstream. The noble gases are helium, neon, argon, krypton, xenon and radon.

**Nuclear Regulatory Commission (NRC)**
The independent civilian agency of the federal government with the authority to regulate, inspect and oversee the nuclear industry to assure the safe use of nuclear materials in research, industry, and nuclear power plants.

**Nuclear Power Plant**
A facility designed to convert nuclear energy into electricity.

**Nuclear Steam Supply System (NSSS)**
The systems in a nuclear power plant that provide steam for use in the turbine-generator. In a BWR, this includes the reactor and its internal components; in a PWR, this includes the reactor, the pressurizer, the steam generators and associated piping.

**Nucleus**
The center of an atom which contains protons and neutrons. Although the nucleus is only about 1/10,000 of the diameter of an atom, it contains nearly all the mass of an atom.

**Personnel Monitoring**
The determination of an individual's radiation dose by using devices such as a pocket ionization chamber or TLD (thermoluminescent dosimeter).

**Pico – (symbol: p)**
A prefix meaning one trillionth (example picocurie).

**Plume**
An invisible cloud (that could be released in a severe accident ) of airborne radioactive particles moving away from a nuclear plant and in a direction and at a speed determined by the prevailing wind.

**Plume Exposure Pathway EPZ**
For planning purposes, the area within approximately a 10-mile radius of a nuclear plant site where the principal exposures in the event of an accident would be external exposure to gamma radiation from the plume and contamination, and inhalation exposure to all radiation types from the plume.

**Potassium Iodide (symbol: KI)**
A stable form of iodine taken orally to prevent the uptake of radioactive iodine by the thyroid.

**Pressurized Water Reactor (PWR)**
A reactor design in which water flowing through the reactor is heated to high temperatures by nuclear energy, but is kept at high pressure to keep the water from boiling. This heated water then transfers its heat to a secondary water system, which boils into steam to drive the turbine.

**Pressurizer**
A steel tank, containing steam and water, used to control pressure in the reactor coolant system.

**Primary Loop**
In a PWR, the closed cooling system containing radioactive water that consists of the reactor vessel, steam generator, reactor coolant pump, pressurizer and associated piping. Heat produced in the reactor is transferred via the reactor coolant across the tubes I the steam generator to the secondary loop.

**Protective Action Guideline (PAG)**
The projected dose, at which protective actions such as shelter in place, evacuate, should be initiated.

**Proton**
A subatomic particle with a positive charge and a mass 1,837 times that of an electron. The number of protons in the nucleus of an atom determines its identity as an element.

**Radiation**
Energy in the form of rays or particles, in the context of nuclear energy, the term refers to iodizing radiation.

**Radiation Absorbed Dose (RAD)**
A unit of dose that measures the amount of energy absorbed from ionizing radiation per gram of absorbing material. It is 100 times smaller than a gray.

**Radioactivity**
The property of the nuclei of energetically unstable atoms, such as radon or uranium, spontaneously emitting radiation to achieve stability.

**Radioisotope**
An unstable isotope of an element that decays spontaneously, emitting radiation.

**Radiological Emergency Response Plan**
A detailed plan that describes and coordinates the EROs, responsibilities, and capabilities of utilities, local, state or federal government, and private organizations to ensure public health and safety during an emergency involving a radiological release.

**Reactor Coolant Pump (RCP)**
In a PWR, a large pump designed to move the coolant through the reactor core to cool the reactor and to transfer the heat produced in the core to the steam generator.

**Reactor (Vessel)**
A cylindrical steel vessel that contains the nuclear core, control rods, coolant, and core support structures, It is constructed of steel approximately six to eight inches thick.

**Reception Center**
A pre-designated facility outside the Plume Exposure Pathway EPZ where the evacuated public can register, receive assistance contacting others, receive directions to congregate care centers, reunite with others, and receive general information.

**Recovery**
The actions taken to restore the radiologically affected area, as nearly as possible, to pre-emergency condition.

**Redundant System**
A system in a nuclear power plant with at least two independent subsystems that accomplish the same task. The backup system automatically takes over if the first system should fail for any reason.

**Reentry**
The provisions for the return of the public, after evacuation, once the radiation risk has been reduced to acceptable levels.

**Refueling**
A reactor condition in which the reactor is shut down, and reactor coolant system temperature is below 140 degrees F. The reactor vessel head may be removed, allowing for the movement of fuel assemblies. (Also known as Mode 6 in a PWR.)

**Relief Tank**
A tank designed to condense and store steam and water, discharged through the pressurizer relief valves, in the event of high reactor coolant system pressure.

**Relief Valve**
A valve that automatically opens to release steam or water and prevent excessive pressure buildup.

**REM – See "Roentgen Equivalent Man"**

**Residual Heat Removal System (RHR) or "Shutdown Cooling"**
A system designed to remove heat produced by the core after the reactor is shut down and the fission process is terminated. The system normally operates during core cooldown and refueling operations.

**Restricted Area**
Any area to which access is controlled for the protection of individuals from exposure to radiation and radioactive materials.

**Roentgen**
A unit of measure for gamma or x-radiation that indicates the amount of radiation energy absorbed by air.

**Roentgen Equivalent Man (REM)**
A measure of radiation dose that indicates the potential biological impact on people. It is a standard radiation dose unit used whenever human exposure is concerned.

**Safeguards**
The protection of special nuclear material (enriched uranium or plutonium) to prevent theft, loss, or sabotage.

**Safety Injection Tanks**
In a PWR, tanks containing borated water and pressurized with nitrogen that will inject massive amounts of water into the reactor in the event of a large-break LOCA during which reactor coolant pressure drops below the nitrogen pressure. Also known as accumulators.

**Scram**
The rapid shutdown of the reactor, either automatically or manually, by the full insertion of all the control rods. Also known as a reactor trip.

**Secondary Loop**
In a PWR, the closed cooling loop containing non-radioactive water that consists of the steam generator, turbine, condenser and associated pumps and piping. Heat from the primary loop is transferred across tubes in the steam generator, causing water in the secondary loop to boil, which produces steam used to spin the turbine.

**Sheltering**
A process of utilizing a structure or barrier to provide an effective shield from radiation.

**Shielding**
Material, such as lead or concrete, that absorbs radiation and is used to protect workers and equipment from exposure to radiation.

**Sievert – (symbol: Sv)**
A measure of radiation dose that indicates the potential biological impact on a human. It is 100 times larger than a rem. It is a standard radiation dose unit used whenever human exposure is concerned.

**Site Area Emergency**
The second highest emergency classification.

**Site Boundary**
The area surrounding a nuclear plant site where the utility has the authority to determine and control all activities, including exclusion or removal of personnel and property from the area.

**Source Term**
The type, mixture and total amount of radioactive material in a nuclear power plant available to escape to the environment at the release point.

**Special Facility**
A facility with a population that may require special protective action considerations, such as a hospital, a school, or a nursing home.

**Spent Fuel**
Used nuclear reactor fuel that can no longer sustain a chain reaction.

**Spent Fuel Pool**
A pool constructed of reinforced concrete, lined with stainless steel, used for the underwater storage of spent fuel assemblies after their removal from the reactor.

**Stack**
The release point for gases emitted by a nuclear power plant.

**Startup**
A reactor condition in which the reactor is critical but less than 5% power. Also known as Mode 2 in a PWR.

**Steam Generator**
In a PWR, the heat exchanger within which heat is transferred from water in the primary loop to water in the secondary loop through tubes. The radioactive water of the primary loop does not contact the non-radioactive water of the secondary loop.

**Surface Contamination**
The unwanted deposition and attachment of radioactive materials to a surface.

**Surveillance**
A routine test performed on equipment at a nuclear power plant.

**Survey Instrument**
A portable radiological monitoring instrument used to detect and measure ionizing radiation.

**Switchyard**
The plant area that contains the electrical equipment connecting the plant's electrical output to the regional transmission grid.

**Technical Specifications (Tech Specs)**
The written specifications that provide the conditions under which the nuclear power plant can be operated.

**Total Effective Dose Equivalent (TEDE)**
The total occupational radiation exposure received by nuclear power plant workers, summing internal and external exposures. The TEDE limit for occupational exposure is 5,000 millirem/year.

**Thermoluminescent Dosimeter (TLD)**
A devise used to measure an individual's radiation dose by adsorbing part of the energy from the radiation and storing it in crystalline chips. When heated, the TLD releases the stored energy as a measurable amount of light that is proportional to the radiation dose received.

**Train**
One of at least two redundant systems or sets of equipment.

**Transient**
A deviation from normal operating conditions that can usually be controlled by minor adjustments without shutting down the reactor. A significant transient can result in a reactor shutdown and/or activation of emergency systems.

**Transient Population**
Individuals, such as tourists, who do not permanently reside in the plume exposure pathway or Emergency Planning Zone (EPZ), but may be present during an emergency.

**Transportation-Dependents**
People without access to a vehicle for leaving the plume exposure pathway, at the time of an evacuation.

**Trip**
An automatic or manually initiated procedure by which control rods are rapidly inserted into the core of a reactor to stop the fission process. Also known as a SCRAM.

**Turbine Stop Valves**
Valves designed to stop steam flow to the turbine in the event of a loss of electrical load on the generator, preventing turbine acceleration and possible damage.

**Unusual Event**
The lowest emergency classification.

**Uranium (Symbol: U)**
A radioactive element that is the basic fuel in a nuclear reactor, with the atomic number 92 and an average atomic weight of approximately 238 (as found in nature). The two major natural isotopes are U-235 (0.7 % of natural uranium), which is fissionable, and U-238 (99.3% of natural uranium), which is not readily fissionable.

**Void**
An area of lower density in the moderator of a reactor core, due to the formation of steam bubbles in the water with sufficient core heat output. This allows more neutrons to escape from the core, leaving fewer neutrons available for fission, which, as a self-regulating feature of reactors, reduces power output.

**Waste, Radioactive**
Materials that are radioactive or contaminated and have no further use. Wastes are generally classified as high-level or low-level.

**Waste Storage Tank**
A holding tank for liquid or gaseous waste, which may be radioactive, prior to processing for disposal.

**Watt**
A unit of electrical power. Most power plants express their generating capacity in kilowatts (1,000 watts) or megawatts (1,000,000 watts).

**Zircaloy**
An alloy of the element zirconium, highly resistant to corrosion, used as cladding on nuclear fuel assemblies.

**Zirconium**
A metallic element, highly resistant to corrosion, used in alloys for cladding on nuclear fuel elements.

**Zirc-Water Reaction**
A chemical reaction that can take place between fuel cladding and water under extremely high temperatures in the event of a reactor accident. The reaction can bind oxygen from water molecules to the zirconium, creating hydrogen gas.

# 7

## Nuclear And Electrical Power Acronyms

| | |
|---|---|
| AC | Alternating Current |
| AFS | Auxiliary Feed water System |
| ALARA | As Low As Reasonable Achievable |
| ANI | American Nuclear Insurers |
| ANS | American Nuclear Society |
| ANSI | American National Standards Institute |
| APR | Automatic Pressure Relief |
| APRM | Average Power Range Monitor |
| DEHMS | Dept. of Emergency Management and Homeland Security |
| ARC | American Red Cross |
| ASDV | Atmospheric Steam Dump Valve |
| ASLV | Atomic Safety and Licensing Board |
| ASME | American Society of Mechanical Engineers |
| ATWS | Anticipated Transient Without Scram |
| BWR | Boiling Water Reactor |
| CAR | Containment Air Recirculation (system) |
| CDC | (Federal) Centers for Disease Control |
| CPM | Counts Per Minute |
| CFR | Code of Federal Regulations |
| CL&P | Connecticut Light and Power |
| CR | Control Room |
| CRDM | Control Rod Drive Mechanism |
| CSS | Core Spray System |
| CST | Condensate Storage Tank |
| CVCS | Chemical and Volume Control System |
| DBA | Design Basis Accident |
| DC | Direct Current |
| DEMHS | Department of Emergency Management and Homeland Security |
| DEP | (CT) Department of Environmental Protection |
| DOE | (U.S.) Department of Energy |
| DOT | (U.S. or CT) Department of Transportation |
| DNC | Dominion Nuclear Connecticut |
| DPM | Disintegrations Per Minute |
| DRD | Direct Reading Dosimeter |
| DSEO | Director of Station Emergency Operations |
| EAS | Emergency Alert System |
| EAL | Emergency Action Level |
| ECCS | Emergency Core Cooling System |
| EDG | Emergency Diesel Generator |

| | |
|---|---|
| EFPD | Equivalent Full Power Days |
| ENRS | Emergency Notification and Response System |
| EOC | Emergency Operations Center |
| EOF | Emergency Operations Facility |
| EOP | Emergency Operating Procedure |
| EPA | (U.S.) Environmental Protection Agency |
| EPZ | Emergency Planning Zone |
| EPRI | Electric Power Research Institute |
| ERF | Emergency Response Facility |
| ERO | Emergency Response Organization |
| ESST | Emergency Station Service Transformer |
| ETE | Evacuation Time Estimate (Study) |
| FDA | (U. S.) Food and Drug Administration |
| FEMA | Federal Emergency Management Agency |
| FERC | Federal Energy Regulatory Commission |
| FFD | Fitness For Duty |
| FSAR | Final Safety Analysis Report |
| FWCI | Feed Water Coolant Injection (System) |
| GE | General Emergency |
| HEPA | High Efficiency Particulate Air Filter |
| HLW | High-Level Waste |
| HP | Health Physics/High Pressure |
| HPSI | High Pressure Safety Injection |
| HVAC | Heating, Ventilation and Air Conditioning |
| I&C | Instrumentation and Control |
| ILRT | Integrated Leak Rate Test |
| INPO | Institute of Nuclear Power Operations |
| IRF | Incident Report Form |
| ISI | In-service Inspection |
| JMC | Joint Media Center |
| KI | Potassium Iodide (chemical abbrev.) |
| KW | Kilowatt |
| KWh | Kilowatt-hour |
| LCO | Limiting Condition for Operation |
| LER | Licensee Event Report |
| LLW | Low-Level Waste |
| LOCA | Loss of Coolant Accident |
| LPCI | Low Pressure Coolant Injection |
| LPSI | Low Pressure Safety Injection |
| LPRM | Low Power Range Monitor |
| MP | Millstone Point or Millstone Power Station |
| MR | Millirem (1/100rem) |
| MRCA | Manager of Radiological Consequence Assessment |
| MRS | Monitored Retrievable Storage (facility) |
| MSIV | Main Steam Isolation Valve |
| MW | Megawatt |
| NCRP | National Council on Radiation Protection (and Measurement) |
| NEI | Nuclear Energy Institute |
| NNM | Nuclear News Manager |
| NPRDS | Nuclear Plant Reliability Data System |
| NRC | U. S. Nuclear Regulatory Commission |
| NSSS | Nuclear Steam Supply System |

| | |
|---|---|
| NSST | Normal Station Service Transformer |
| NUREGS | Nuclear Regulations |
| OFIS | Off-Site Facilities Information System |
| ORO | Offsite Response Organization |
| OSC | Operational Support Center |
| PAB | Primary Auxiliary Building |
| PAD | Protective Action Decision |
| PAG | Protective Action Guide |
| PAR | Protective Action Recommendation |
| PASS | Post Accident Sampling System |
| PCs | Protective Clothing |
| PDCR | Plant Design Change Request |
| PEO | Plant Equipment Operator |
| PIR | Plant Incident Report |
| PRA | Probabilistic Risk Assessment |
| PSI | Pounds per Square Inch |
| PWR | Pressurized Water Reactor |
| PZR | Pressurizer |
| RAD | Radiation Absorbed Dose |
| RCA | Radiological Control Area |
| RCP | Reactor Coolant Pump |
| RCS | Reactor Coolant System |
| REM | Roentgen Equivalent Man |
| RERP | Radiological Emergency Response Plan |
| RHR | Residual Heat Removal System |
| RIEMA | Rhode Island Emergency Management Agency |
| RMT | Radiation Monitoring Teams |
| RO | Reactor Operator |
| RP | Radiation Protection |
| RPM | Revolutions Per Minute |
| RSST | Reserve Station Service Transformer |
| RVLS | Reactor Vessel Level Indication System |
| RWP | Radiation Work Permit |
| RWST | Refueling Water Storage Tank |
| Rx | Reactor |
| SAE | Site Area Emergency |
| SERO | Station Emergency Response Organization |
| SPDS | Safety Parameter Display System |
| SRO | Senior Reactor Operator |
| STA | Shift Technical Advisor |
| TEDE | Total Effective Dose Equivalent |
| TG | Turbine Generator |
| TLD | Thermoluminescent Dosimeter |
| TODE | Total Organ Dose Equivalent |
| TS | Technical Specification |
| TSA | Transportation Staging Area |
| TSC | Technical Support Center |
| UE | Unusual Event |
| USCG | U.S. Coast Guard |
| USDA | U.S. Department of Agriculture |
| WB | Whole Body |

# Additional Information Sources:

- United States Nuclear Regulatory Commission:
  Radiation Information
  http://www.nrc.gov/what-we-do/radiation.html

- Regulatory Guide 8.13 - Instruction Concerning Prenatal Radiation Exposure
  (http://www.nrc.gov/reading-rm/doc-collections/reg-guides/occupational-health/active/8-13/)

- 10cfr20–Standards For Protection Against Radiation
  http://www.nrc.gov/reading-rm/doc-collections/cfr/part020/

- Nuclear Energy Institute
  http://www.nei.org/index.asp?catnum=2&catid=54

- Environmental Protection Agency
  http://www.epa.gov/radiation/

- CT Department of Emergency Management and Homeland Security
  http://www.ct.gov/demhs

- Dominion Resources
  http://www.dom.com/about/stations/nuclear/emerplan/index.jsp

# Map/Directions to the Emergency Management Joint Media Center

Hartford, CT

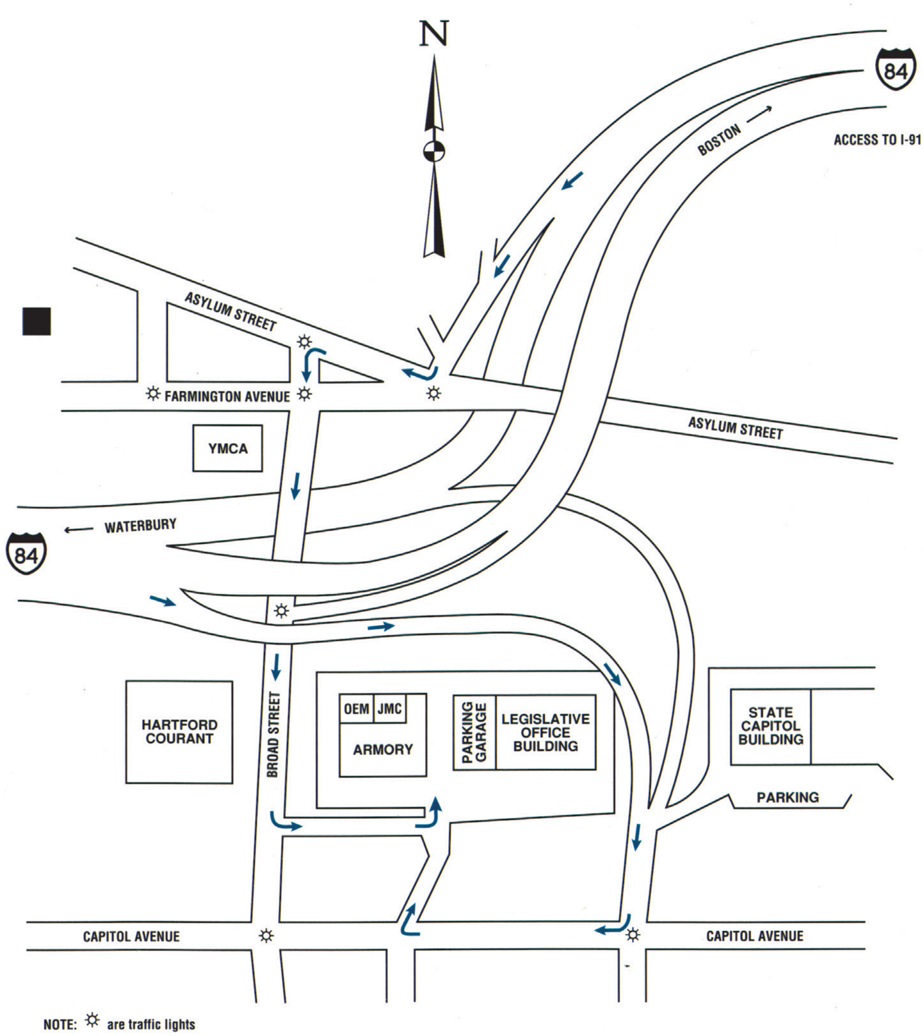
From I-91 North - In Hartford, take I-84 West; see below.

From I-91 South - In Hartford, take I-84 West; see below.

From I-84 West - Take Asylum Street exit. Turn right at end of exit. Take first left onto Broad Street (in front of YMCA). Hartford Armory is on the left, across from the Hartford Courant.

From I-84 East - Take Capitol Avenue exit. Turn right at end of exit. Take first right into parking area. Hartford Armory is directly ahead of you on the left; parking garage is on the right.

NOTE: Enter at ground level of east side of building. Go straight down passageway to the end. Joint Media Center is on the right.



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